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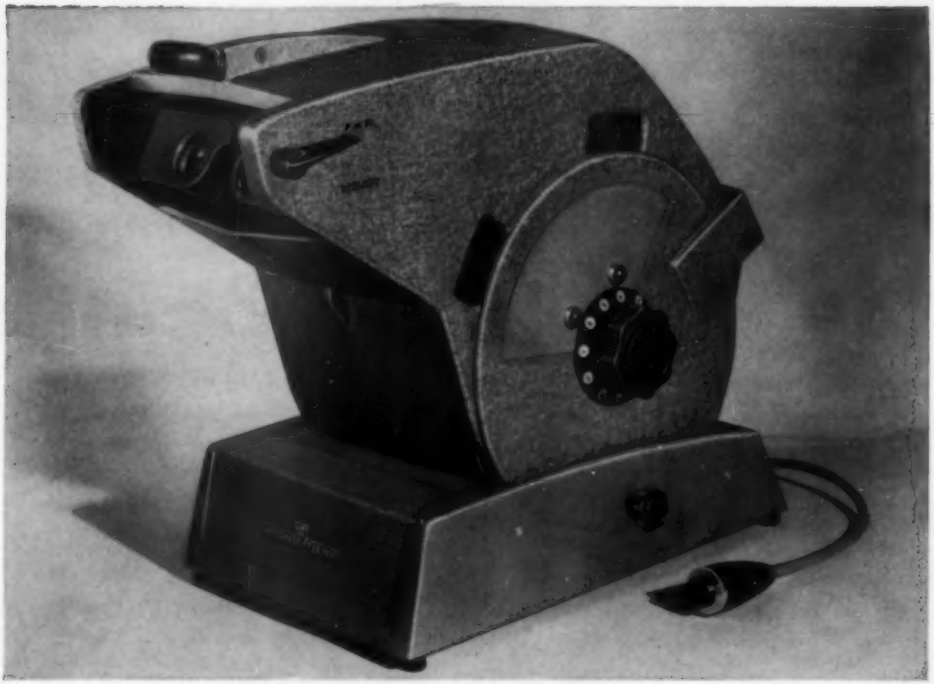

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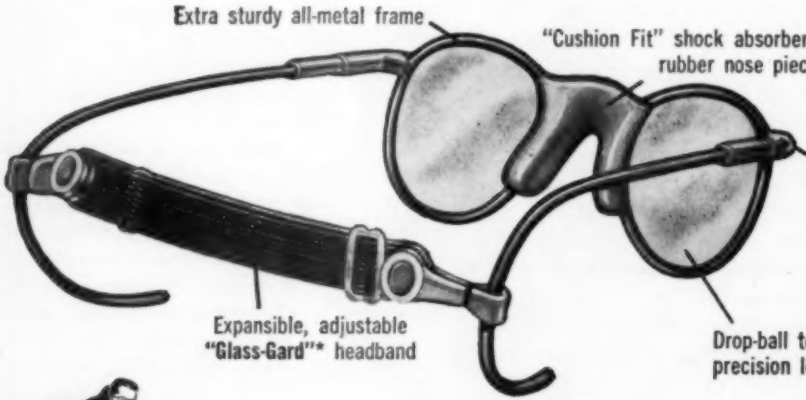
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THE RELATIONSHIP OF FREQUENCY OF USE OF THE EYES IN CLOSE WORK TO THE DISTRIBUTION OF REFRACTIVE ERROR IN A SELECTED SAMPLE*

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Ojai, California

INTRODUCTION

Data pertinent to the still unresolved question concerning the etiology of the refractive state are offered herein. The material was obtained by the senior author as part of the research for the doctoral dissertation, which attempted to evaluate sociologically the validity of the environmental approach to this problem.[1] The method of performing the refractions and gathering the sociological data, together with the explanation for classifying the refractive categories as hypermetropia, myopia, and modal, have been discussed in an earlier article.[2] Before the data are examined, a brief review of the literature will be made.

HISTORICAL

The problem is whether myopia can be developed as a result of intensive use of the eyes in tasks performed at a near distance, or whether it comes about primarily as a biological phenomenon. In the latter view, myopia represents the end-product of the differential growth of the optical elements of the eye, and is thought specifically to be due to an axial length - corneal curvature imbalance.[3, 4] Related to this is the factor of relative growth of various parts of the body, myopia developing in those children in whom growth of certain parts is unusually rapid.[5]

The environmental point of view, which has been labeled "the use-abuse" theory,[6] is that myopia develops (during the formative years?)

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as a result of too constant application of the eye at near work. One of the earliest proponents of this belief, which remains essentially unchanged today, was Hermann Cohn.[7] Donders speculated upon five ways in which prolonged near vision might operate to produce a myopic eye, and at least an equal number of explanations was subsequently adduced by others.[8] Stansbury has provided the necessary evaluation of the earlier theories.[9]

Criticisms of both the environmental and the biologic explanations have recently been made by Young.[10] He believes that the intercorrelation of the presumably (?) independent optical elements of the eye with each other and with the refractive power weakens the biologic theory. The proponents of the latter, however, interpret this correlation to mean that an "emmetropization factor" exists, which regulates the rate and period of growth of each variable in such a way as, in most cases, to produce a post-adolescent refractive state close to emmetropia. This emmetropization factor is an example of the principle of allometric growth commonly encountered in biological phenomena, and actually supports the biologic theory.

Early statistical-type studies of the relationship between near work and the refractive state fail to establish the nature of this relationship clearly. Tscherning[11] and Seggel[12] analyzed the incidence of refractive error in the military services in Germany on the basis of previous civilian activities, but failure to appreciate the sociological difference between social class and occupation and to apply tests of statistical significance are serious drawbacks.

Not only in Germany, but in Russia, England, and France, various investigators purported to find a relationship between use of the eyes in close work and the incidence of myopia.[13] Since none of these studies appears to meet the demanding criteria concerning sampling methods and statistical techniques postulated by Hirsch as necessary for obtaining valid and reliable generalizations,[14] the reliance which may be placed upon such findings is difficult to assess.

Witte's investigation of 34,753 German subjects yielded results which seem to suggest that the myopia-near work relationship is a peculiarly complicated one, for myopes of *low* degree were found to have engaged in considerable close work, whereas myopes of *high* degree did very little near work![15]

Another type of study which is at variance with the environmental explanation is that of Holm, who found that little myopia existed in a group of African natives, regardless of their degree of literacy.[16] Additionally, Duke-Elder has cited data indicating a high degree of illiteracy

and considerable myopia among Arabs. It is also shown that, though Egypt and the Sudan are contiguous areas (with presumably congruous culture patterns), the incidence of myopia in the former country is high, whereas in the latter it is low.[17]

Recent issues of this Journal have dealt with a number of papers relating to the environmental aspects of the refractive etiology. In the Pullman study,[18] a comparison was made of the refractive condition of children doing considerable near work with those doing little close work. Children of a college community were chosen to represent the former group, those of a rural area to represent the latter. Refractive state was determined by means of static retinoscopy, the fogging technique being employed to relax the accommodation fully.*

Part I of the Pullman study compared the sampling of children from the college community with the samplings described in papers by Hirch and by Kempf, Collins, and Jarman. Considerably more myopia was found in the Pullman group, leading Young *et al* to conclude that children of college instructors are more likely to be myopic than children drawn from the general population. There is no explanation as to why the Pullman sample should show both an earlier incidence and a greater frequency of myopia than found in the other studies. All authors seem to agree concerning the effects of age and sex difference upon the distribution of refractive errors.

In the most recent paper summarizing the results of the Pullman research, Young found no significant difference between myopes and hypermetropes in relation to the following variables: diet, height, weight, and I.Q.[19] More pertinent to our data, Young presented the

*The method of elucidating the refractive error constitutes one of the most important variables in explaining many of the discrepancies existing between various studies of the refractive state. Early investigations utilized ophthalmoscopic estimates of the refractive error; later studies, using the static retinoscopic findings, were based upon cycloplegic means of relaxing the accommodation, which yields results more on the hypermetropic side than obtain when the fogging technique for accommodative relaxation is employed. The latter appears to be the most satisfactory of the non-cycloplegic methods for controlling accommodation, and avoids the artificial relative hyperopia induced by cycloplegics.

Further, the vexing question remains as to whether to represent the refractive condition by meridional findings or by equivalent spheres, and, if the latter, whether to use these monocularly or binocularly. A further problem is what to do with cylinder findings. Since each investigator has handled these problems differently, it is unlikely that more than a handful of the studies extant are strictly comparable in method of delineating the refractive states.

The question may also be raised concerning just what refractive condition emmetropia properly represents in the various analyses, since varying criteria of the fundus reflex may be employed and different retinoscopists may possess different degrees of accuracy. These questions are raised merely to demonstrate the difficulties that beset the investigator who attempts to reconcile the masses of data so far accumulated in the study of the etiology of the refractive state of the human eye.

results of comparing the myopes and the non-myopes on the basis of the number of hours per week spent in close work, i.e., at twenty inches from the eye. This included reading, housework, sewing, hobbies, and recreation. School and non-school activities were combined.

By means of partial correlation techniques (age partialled out), it was found that a myopic trend was associated with a greater time spent in reading. The relationship was small but significant. However, it was stated that the relationship is too small to account for the present incidence of myopia, and the nature of the reading—myopia relationship still remains to be elaborated, as well as the relative importance of the reading as compared to the heredity factor. (Possibly this could be assessed by the analysis of variance procedure.)

In another study in which professional and managerial occupations of the fathers were characteristic of a large percentage of the children, Haines traced through a period of some eight years the scholastic and visual records of thirty-eight children.[20] Just how the measurement of the refractive state was made is not clear, but it seems that several methods and a number of examiners were involved, which might introduce an indeterminate amount of variability into the data.

This study treats myopia as a qualitatively distinct refractive category (in contrast to the biologic-statistical treatment of it as one end of a normal distribution curve), having connotations of pathology. It is felt that the myopia is induced by near work, and that high esophoria, poor visual habits, and a general visual handicap are associated with this condition. The relationship between visual and academic performance has also been noted by others, though it has been *hypermetropia* which has been associated with the type of visual handicaps and inadequate school performance described by Haines.[21, 22]

Haines' study shows that, over the period of years, there is an overall change in the mean refractive state of 1.2 diopters less hypermetropia. This is in accordance with what is usually found. It is not, of course, indicative *per se* of near work causation, as the many studies of the last few decades have shown.

Kephart and Unger attacked the near work-myopia relationship by comparing the static refractions before and after the summer vacations of two groups of students—one rural, the other urban.[23] Ten children, apparently randomly selected in each grade, from four through eight, constituted the subjects of each group. The data were statistically examined by the method of analysis of variance. It was found that (a) the urban group was more myopic, the difference between means being at the one per cent level of significance; and (b) there was sig-

nificantly less myopia after the summer vacation than before.

These findings are at variance with those of Hirsch. Kephart and Unger noted that Hirsch previously had found little change during the summer vacation, and that in a direction of increased myopia (or decreasing hypermetropia). The reason for the contradictory results is not clear, unless the sampling methods are responsible. That this may be the case is suggested by the fact that Kephart and Unger found the mean, even of their rural group, to be on the myopic side (—0.008 diopters), whereas, Hirsch found, in his analysis of 9,552 randomly selected children, that fewer than twenty-five per cent of the boys and about this per cent of the girls aged 13 to 14 had a refractive error of —0.01 diopters or more on the myopic side. For the younger ages, of course, the mean was even more toward the hypermetropia side.[24]

From a sociological point of view, all studies reviewed suffer from the oversimplification of human behavior. It would appear as if most school, occupational, and cultural behavior is merely a manifestation of visual phenomena! Personality is far too complex to be "explained" as the result of a given type of refractive condition.

Most of the studies of the nineteenth century and early twentieth century, especially those carried out in Europe, also fail to appreciate some rather important sociological factors and their genetic implications. Some of the societies studied have displayed a great measure of social stratification, with consequently little vertical social mobility. In practical terms, this means a restriction on the amount of intermarriage that will occur between classes stratified on the basis of economic, social, and cultural characteristics.[25, 26, 27]

With confinement of marriage essentially to members of a given class, and with minimum infusion of new genetic characteristics in areas of little geographic mobility, the genetic differences between the classes of such a society might prove considerable over a period of several generations. Therefore, for example, not the occupation *per se*, but its social significance as a criterion of social stratification, may be the important factor in the apparent relationship of type of occupation to the extent of myopia. If so, then this really represents a biological quite as much as an environmental factor in the development of the refractive state.

It is also apparent that many past investigations have confused ethnic (i.e., cultural) groups with racial (i.e., biological) categories in three ways:

a. some have considered groups of the same race but of different cultural characteristics as separate racial categories;[28, 29]
b. others have failed to distinguish the differential hereditary char-

acteristics of different races with the same cultural characteristics;[30, 31]

c. still others have failed to differentiate between hereditary and cultural characteristics in groups differing on both counts. This may have had an important bearing on the statical records concerning refractive error distribution among different groups.[32]

Finally, sociological criticism can be made concerning the assumption that the rural-urban classification represents distinct forms of behavior which could influence the refractive state. Specifically, those who make this assumption must show that urban children get more schooling, or do more homework, or otherwise use their eyes more at the near point in non-school activities than is true of the rural group. Many rural areas have lost their bucolic aura (if, indeed, some of them ever had it) and are rather decentralized suburbia of large metropolises. It is also a mistake uncritically to assume that urban areas are homogeneous in respect to use of the eyes (*inter alia*). The wide variation in extent of schooling with type of neighborhood in which the individual resides has been clearly demonstrated by Bell and Force.[33] If homogeneity in this regard is greater in smaller urban communities, it must be proved and not taken for granted.

The urban-rural differential also involves a host of other factors, none of which has been considered by the various studies examined. These factors relate to differentials in fertility and mortality rates, the selective nature of rural-urban migrations, the variations in population growth and distribution of both white and non-white population, and differences in social stratification between and within urban and rural communities. The theoretical and practical sociological and genetic implications of all these factors makes it unwise to employ rural-urban differentiation as a simple representation of differences in amount of near work done.[34]

Several points of logic remain to be cleared up in the literature. Some studies (for example, Kephart and Unger) have found a significant refractive power difference between the two eyes. If environmental influences are primarily responsible for the refractive condition, and presumably these influences are uniform on the two eyes, the finding of a difference between the two eyes requires explanation. If environmental influences are *not* uniformly operative on the two eyes, then it should be explained what factors are at work and *how* they exert differential effects on the two eyes. From a biologic point of view, such inequality is usually explained on the basis of axial length for, (assuming corneal curve and the remaining optical elements to be constant between the two

eyes), a 1 mm. difference in axial length between the two eyes will optically account for a difference of about 3 diopters.

One final theoretical problem needs to be mentioned. Some investigators, though observing the ostensible relationship between myopia and close work, have avoided concluding that the latter caused the former, raising instead the question as to whether myopia may not be the ocular condition most congenial to the demands of near work. Certain papers, such as those of Schwartz[35] and of Dearborn and Leverette,[36] have demonstrated that far-sighted persons are more likely to experience reading difficulties than those who are near-sighted, the latter finding such tasks visually easier to perform. Certainly it is not logical to associate both visual discomfort in near work and greater frequency of near work with the myope. The inference contained in these observations has been formulated by Ochapovsky into the explicit hypothesis that occupational *selection,* rather than causation, may be the reason for the observed working distance—refractive state association.[37]

FINDINGS

The sample upon which the data and conclusions of the present paper are based, and the methods by which the refractive and sociological findings were obtained, have been previously described.[38] The information dealing with the frequency of the use of the eyes at near-point tasks was derived from answers by the subjects to a questionnaire. Since these were all either ninth or tenth grade students in a junior high school, the amount of in-school near work was considered to be essentially the same for all the subjects, with any important differences occurring in the amount of reading or other near work done after school. Such extra-curricular differences are shown in the following four tables.

TABLE I

Distribution of the Sample by Time Devoted to Reading

Number of Hours Reading	Number of Subjects
less than one	132
one to two	194
two to three	54
over three	29
Total	409

Sex differences in reading habits of the sample are given in Table II.

Similar tables relating to the time spent in watching television follow. Table III and IV.

Table V represents the observed and the chance-expected (bracketed) frequencies of each refractive error classification for each time category of reading.

TABLE II
Numerical and Percentage Sex Difference in the Time Devoted to Reading

Time Spent in Reading	Number of Girls	Per Cent of Girls	Number of Boys	Per Cent of Boys
less than 1 hour	56	26.2	76	39.0
1-2 hours	92	43.0	102	52.3
2-3 hours	45	21.0	9	4.6
over 3 hours	21	9.8	8	4.1

TABLE III
Distribution of the Sample by Time Method to Watching Television

Number of Hours Watching TV	Number of Subjects
less than one	77
one to two	100
two to three	112
over three	115
Total	404

TABLE IV
Numerical and Percentage Sex Differences in the Time Devoted to Watching Television

Time Spent in Watching TV	Number of Girls	Per Cent of Girls	Number of Boys	Per Cent of Boys
less than 1 hour	43	20.7	34	17.3
1-2 hours	45	21.6	55	28.1
2-3 hours	58	27.0	56	28.6
over 3 hours	64	30.8	51	26.0

TABLE V
Contingency Table of Observed and Expected Refractive Distribution According to the Amount of Time Spent in Reading

	Less Than 1 Hour	1-2 Hours	2-3 Hours	More Than 3 Hours	
Modal	90	138	37	17	282
	(91)	(134)	(37)	(20)	
Myopes	17	24	6	8	55
	(18)	(26)	(7)	(4)	
Hypermetropes	25	32	11	4	72
	(23)	(34)	(10)	(5)	
Total	132	194	54	29	409

The X^2 (Chi-square) of this distribution is 5.52, with 6 degrees of freedom (n). The resulting probability, P, is .50. Therefore, there is no significant difference in the number of myopes, hypermetropes, or modal on the basis of the amount of reading each group does.

Because two groups in the above contingency table had 5 or fewer expecteds, which leads to a skewed distribution of such frequencies about the observed frequency,[39] the data were analyzed by the Kolmogorov-

Smirnov test, which is based on the sample cumulative percentage polygon and is sensitive to any kind of a difference in the sample distribution.[40] The significance of the maximal vertical distance between the two polygons, D, is given by the formula:

$$a \text{ (alpha)} = \sqrt{1.95 \frac{N_1 + N_2}{N_1 N_2}},$$

where alpha is the .001 level of significance.

The maximum difference between the frequency polygons of the myopes and hypermetropes was 8.9 per cent (with more of the *hypermetropes* doing the specified amount of reading), which is so much smaller than the 35 per cent difference needed to attain the 0.01 level of significance (as calculated by the above formula) that it would not achieve even the five per cent level. In consequence, the difference in the number of hypermetropes and myopes who read for a given length of time is not significant. By carrying through a similar analysis for all three refractive categories, it was found that there is no significant difference between the myopes, hypermetropes, and modal on the basis of the amount of reading done. Interestingly enough, the observed differences were in the direction of *more* reading by the hypermetropes and the modal group.

Results similar to the above were obtained when the refractive distribution was examined on the basis of the time spent in watching television. The distribution (not shown here*) yielded a X^2 of 6.03 for n equal to 6. The resulting P was greater than .30 and less than .50. Furthermore, on comparing the extremes—those who devote less than one hour each to reading and watching television, and those who spend over three hours in both activities—there was again no significant difference in the number of myopes, hypermetropes, and modal.

For the distribution, as shown in Table VI, the X^2 is 2.49, with 2 degrees of freedom, yielding a P of .30.

Again, because of the very small numbers in most of the groups of the above table, it was decided to employ the Kolmogorov-Smirnov test. As before, the differences in refractive state distribution were not significant, alpha of .001 requiring a D of 123 per cent, which is far greater than the observed difference in the cumulative percentage polygons of myopes and hypermetropes of 7 per cent. In this case, too, the tendency was for the *myopes* to use their eyes less at near.

*Due to limitations of space, only a few of the contingency tables are shown. The remainder may be found in the writer's unpublished doctoral dissertation, "Socio-Cultural Factors Related to the Incidence of Visual Refractive Errors." The University of Southern California, 1954, Technical Appendix, Series A, pp. 290-97.

TABLE VI
Contingency Table of the Distribution of Refractive Error for Both Slight and Excessive Use of the Eyes

	Modal	Myopes	Hypermetropes	
Less Than 1 Hour Devoted to Reading and TV, Each	16 (14)	4 (5)	2 (3)	22
More Than 3 Hours Devoted to Reading and TV, Each	4 (6)	3 (2)	2 (1)	9
Total	20	7	4	31

The data in the preceding contingency table were also analyzed by the log factorial chi-square method shown by Walker and Lev.[41] Using their formula and the factorial tables of Fisher and Yates,[42] it was found that the distribution shown in Table VI could occur by chance about once in four times (P equal to .2335). Therefore, the distribution is not significant statistically.

The sex differences in both reading and watching television (Tables II and IV), when analyzed by the conventional chi-square method, revealed that the girls do significantly more reading than the boys, but that the two sexes do not differ appreciably in the extent to which each watches television. For the reading category, P was less than .001 for a X^2 of 33.61 and 3 degrees of freedom.

Since the girls read significantly more than the boys, the logic of the near work theory would require that there be a greater number of myopes among the girls. Now, although this was found to be the case on the basis of comparison of the refractive state distribution by sex,* there was no such sex difference in refractive error when the girls and boys were compared on the reading factor.

First, the refractive error distribution based upon the amount of reading was analyzed for each sex separately. In neither case was the refractive difference based on the extent of reading statistically significant, as demonstrated in the following table. Table VII.

With reference to the girls, the values in each group of the foregoing table are sufficiently large to accept the X^2 as it stands; however, because there are several small values in the table for the boys, the log factorial chi-square methods and Fisher and Yates factorial tables were again employed. The myope - modal distribution yielded a P of 0.275,

*For X^2 of 11.89 and n equal to 2, P was less than .01 but greater than .001. (Nadell, *op. cit.*, p. 152.) Yet it was also found that the *mean* refractive differences between the boys and the girls was only 0.02 diopters, the girls having a mean refractive state of +0.32 diopters, the boys, +0.34 diopters. This was clearly not significant. (*Ibid.*, Appendix B-1, pp. 316-17.) These contradictory results serve to illustrate how the arithmetic mean may prove to be misleading.

TABLE VII

Contingency Table of the Distribution of Refractive Error According to the Amount of Reading Done, for Boys and for Girls, Separately

BOYS

	Less Than Two Hours	More Than Two Hours	
Myopes	14 (15)	2 (1)	16
Modal	137 (137)	13 (13)	150
Hypermetropes	27 (26)	2 (3)	29
Total	178	17	195

GIRLS

	Less Than Two Hours	More Than Two Hours	
Myopes	27 (27)	12 (12)	39
Modal	91 (91)	41 (41)	132
Hypermetropes	30 (30)	13 (13)	43
Total	148	66	214

For the boys, $X^2 = 1.44$, $n = 2$, and P is less than .50 but greater than .30.
For the girls, $X^2 = 0$, $n = 2$, and P is greater than .99.

and the myope - hypermetrope distribution resulted in a P of 0.327. Hence, the particular distribution of the refractive categories shown in part 1 of Table VII could have occurred by chance about one time in three, and so is not statistically significant.

The refractive distribution was then analyzed by sex for those who did little reading and those who did considerable reading, separately. The refractive state distribution for boys and for girls differed significantly only for those boys and girls who read *less* than two hours, and was *not* significantly different for those who read *more* than two hours.[43]

The sex distribution based upon the amount of reading done was next analyzed for myopes, hypermetropes, and modal separately. In the case of the hyperopes and emmetropes, the sex-based difference in reading habits *was* significant,[44] as analyzed both by the conventional chi-square method and subsequently by the log factorial method.*

*The contingency tables in the dissertation referred to were analyzed by the ordinary chi-square technique, which was satisfactory for the hypermetropic and modal groups. However, since the myopes contained too few frequencies in one cell of the four-fold table, it was decided for purposes of this paper to analyze the data of this group by the more appropriate log factorial method. This yielded a P of .108, which serves to

On the basis of these analyses, we may conclude that, whatever differences in refractive error may be observed between boys and girls, these differences are *not* a function of variation in reading habits.

SUMMARY AND CONCLUSIONS

Analysis of the data fails to reveal any relationship between the amount of reading done and the distribution of the refractive state in the present sample. Furthermore, it has been shown that existing sex differences in refraction cannot be attributed to observed sex differences in reading habits. (No significant sex differences in time spent watching television were found.) These essentially negative findings seem to accord better with the biological, rather than with the environment hypotheses of the origin of myopia.

No important contribution to the problem of the origin of myopia is to be expected from further studies repeating the shortcomings noted in some of the reviews above. To present convincing evidence rather than illustrate beliefs requires the following features:

1. Variables must be controlled so as to eliminate or greatly reduce those influences which might render the results equivocal. For example, in order to assess definitely the use of the eyes in near work on the development of myopia, it will be necessary to rule out the contributions of such physical factors as rate of maturation, initial refractive state, hereditary (genetic) factors, certain childhood diseases which affect the eyes,[45] the wearing or non-wearing of proper correcting lenses (and for how long), and those varieties of myopia considered to be pathologic in nature.

2. Adequate numbers of cases must be studied. That this inadequacy results from lack of time and funds is readily understood. However, a few cases with the best of intentions cannot replace thousands of records.

3. The samples must be adequately representative. Far too many do not represent even the local community from which they were drawn. Groups purporting to represent differences in near work either fail to present clear evidence of such differences or include genetic, ethnic, or other differences which may equally be the cause of refractive differences if these are significant.

4. Representative samples of adequate size require modern statistical treatment for their analysis. Such methods have often been missing.

5. A certain amount of elementary statistical logic must be

confirm the fact that the sex distribution of the myopes on the basis of the number of hours of reading did not depart significantly from chance.

observed. Some of the more recent investigators have noted the fallacy of attributing the observed increase in frequency of myopia with higher school grade to the increased near work involved in the latter grades first, because there is an equally plausible alternative explanation (the increase in physical maturation with progression through the grades), and second, because of the violation of logic in attributing a cause-effect relationship to what can only be observed as a concomitant variation. (Technically, this error is known as the *post hoc, ergo propter hoc* fallacy.)

6. Longitudinal, rather than cross-sectional, studies of the development of the refractive state are needed. To establish the temporal sequential refractive process and to relate these time changes to other events happening at these times (as Hirsch has recently done in the measles-myopia study)[45] offers perhaps the most promising avenue of approach to the problem of determining how and why a particular refractive state develops.

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ANNOUNCEMENT

NATIONAL COUNCIL TO COMBAT BLINDNESS FELLOWSHIPS

The National Council to Combat Blindness announces that it is now accepting applications for its 1958-1959 FIGHT FOR SIGHT grants-in-aid, Research Fellowships and Summer Student Fellowships. The Council—a voluntary non-profit health agency founded in 1946—is engaged in financing research in the field of eye care and encouraging investigators to further study. To date, it has awarded 178 grants and fellowships for these purposes.

Applications will be reviewed by the Council's Scientific Advisory Committee. Appropriate forms may be obtained by addressing: National Council to Combat Blindness, Inc., 41 West 57th Street, New York 19, New York. The closing date for receipt of completed applications for grants and fellowships has been advanced to March 1, 1958, in order to provide ample time for processing and review. The 1957-1958 research allocations amounted to $128,000. These included 24 grants-in-aid, 10 research fellowships and 24 summer student fellowships.

Dr. V. J. Ellerbrock, professor, School of Optometry, Ohio State University, Columbus, has received a second award for work on a comprehensive volume entitled: *Subnormal Vision* describing aids for persons with subnormal vision.

Robert D. Reinecke, O.D., studied under a summer fellowship at the Howe Laboratory of Ophthalmology, Harvard University Medical School, under Dr. David G. Cogan. His work has been accepted for publication in papers entitled, "standardization of Objective Visual Acuity Measurements Using Opticokinetic Nystagmus vs. Snellen Acuity," and "Objective and Subjective Testing of Visual Acuity in Amblyopia."

A MICROLENS MEASURING AID*

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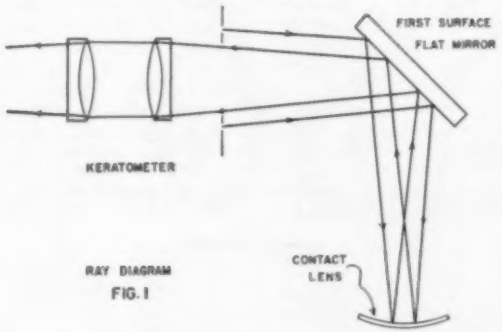
The measurement of the corneal (ocular) curvature of a microlens is usually done with an ophthalmometer. This is generally regarded as a very important check test, to be done before placement of the lens on the cornea, particularly because the lens, due to its thinness and composition, is susceptible to distortion from pressure and temperature changes occurring in handling and mailing.

Ordinarily, the contact lens is held in an erect position by capillary attraction of a film of water or by adhesiveness of toothpaste or a similar substance against a concave holder mounted on the headrest of the instrument. The film of water or toothpaste has a two-fold purpose: first, to hold the lens in position, and, second, to minimize the reflection from the convex surface.

A device has been constructed to permit the mounting of the microlens on a horizontal surface, at the same time allowing the ophthalmometer to remain in its normal horizontal operating position. A chromium-plated, flat, first surface mirror mounted at a forty-five degree angle will reflect to the horizontal, as illustrated in Figures 1 and 2. The contact lens is placed in a horizontal position on a dish-shaped (countersink) lens holder resting on a stage (Figure 2). The



RAY DIAGRAM
FIG. 1

*Submitted on July 23, 1957, for publication in the October, 1957, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
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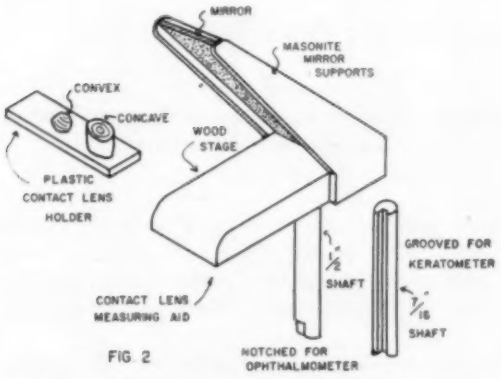

FIG 2

countersink is filled with three or four drops of water, and the lens is placed on the water. The concave surface is then free from the waviness and dullness ordinarily induced when the microlens is suspended erect in the conventional manner, and the mire images from the concave surface are very bright and clear.

The microlens measuring aid, as illustrated in Figure 2, can be used on an ophthalmometer or keratometer depending upon the support rod construction. For other instruments a stand can be used which eliminates the problem of attaching the measuring aid to the instrument.*

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*Appreciation is extended to Dr. M. J. Allen for his assistance in the design.

ANNOUNCEMENT

A.O.A. WOMAN'S AUXILIARY GREETING CARDS

Mrs. Bernard A. Commeree, president of the Woman's Auxiliary of the American Optometric Association, announces a new attractive holiday greeting card for use by optometrists in the coming Christmas Season. The card is in green and white with the Optometric Pledge on the back. The cards are available from State Auxiliaries.

THE OPTICS OF PLANO LENSES*

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SUMMARY

During the past eight to ten years development and production of eye protective devices or "plano" lenses has moved forward faster from the point of view of mechanical and cosmetic design than has the optical design and faster yet than the specifications and tolerances for this type of product.

More and more devices of this general classification are being put into use in private life, in industry and in the military services. Use will further increase as mechanical, atmospheric and radiation hazards increase and as the awareness of these hazards increases.

It is therefore fitting to study the optical and visual problems created by the use of such devices.

By eye protective devices, is meant lenses or shields, transparent devices of any kind whose function is to protect or aid the eyes in some other way than by correcting refractive errors. Safety goggles, sun glasses, color filters, gas masks, welding helmet windows and high altitude helmet visors all fall into this classification. It is frequently true that the better such a device performs its intended protective function, the more it tends to deteriorate the vision of the wearer.

The designer of such a product in order to obtain its necessary protective features, uses curvature, thicknesses and angles of position as variables.

This paper contains a discussion of the effects of these variables on the optical performance of a lens or face shield for a given usage and the effect these dimensions have on the sensitivity of a design to changes in usage, such as changes in angle of view and changes in object distance. The fact that face form angles, steep curves and thick lenses can appreciably affect the performance of protective lenses and shields indicates that care should be used in recommending devices which possess extreme design characteristics, unless there is assurance that the optical performance of the product has been considered in determining the mechanical and cosmetic design. (Figures 1 and 2.)

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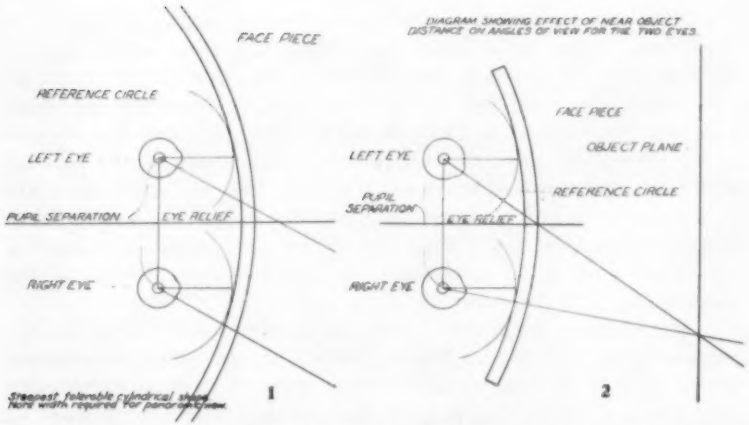


The data presented in this paper point to an inadequacy in present specifications. In some situations lenses which pass specifications would actually be less suitable than some that failed. It is noted that certain apects of visual performance, such as the correlation of accommodation and convergence and the significance of meridional magnification imbalances and accomodative imbalances have been neglected in present specifications. An evaluation of certain lens types in these respects is included.

DISCUSSION

Prior to the war, there were very few "quality" products in use which were not made of ground and polished ophthalmic quality glass. Whenever one paid more than a few cents for a pair of sunglasses, driving glasses, flying goggles, and safety goggles, one expected to get excellent quality ground and polished materials.

Thus the commercial and government specifications for plano lenses, including in this term all non-focus lenses for whatever purpose, were developed on the assumption that the products being tested would be ground and polished, centered lenses. The test procedures which accompany the specifications also assumed that the products were made of ground and polished materials.

During and following the war, the pressure to get out huge quantities of sunglasses, safety shields of various kinds and visors, brought into use plastic materials. There developed a sale of an infinite variety of optical masks of any kind and protective devices, which were not made by grinding and polishing ophthalmic quality glass. Some were dropped, some were blown, some were bent or drawn, the material being either glass or plastic.

The advent of optical quality plastic sheeting, stimulated the use of a bent lens, in one piece masks, face pieces, sunglasses, safety goggles, and various types of flying gear. The fact that one piece of material is used instead of two, for the two eyes, leads to additional problems in design. Here again, specifications did not keep pace with the changes in the fabrication methods. Frequently, specifications for a product would be issued, with sufficient detail so that there was no freedom left in the design and yet optical specifications would accompany these mechanical specifications, calling for optical performance which could not be atttained if the mechanical and physical characteristics of the specifications were followed.

Furthermore, frequently, there was no detail given as to the test procedures. As will be seen later in this report, the optical performance of the piece of material varies with the angle of view at which one's gaze strikes it. This simple fact, often, is not taken into account in outlining test procedures.

Furthermore, the use of plastic materials leads to the possibility of lenticulation in zonal areas which are imperfect. These problems did not occur with ground and polished glass. The practice of sagging and bending, even glass which has been ground and polished, can introduce wrinkles and variations in one portion of the surface to another, which may or may not be detected by the established test procedures, but will most certainly be a factor which seriously affects the visual use of the finished product. These considerations should be considered in issuing specifications but will not be considered in this paper which deals with design errors rather than fabrication errors.

In addition to the factors affecting the quality and optical performance of the final product with which we are concerned, there is the fact that there is more known now about other optical effects which occur in these products. Some of these effects can explain the difficulty that wearers have experienced in using supposedly plano optical materials.

The conventional specifications for a plano lens or mask have been that its focal power shall not exceed certain quantities, that the difference in focal power between two meridions should not exceed certain quantities and that the vertical or horizontal prism shall not exceed certain quantities. Sometimes a prismatic imbalance between the right and left eye is included as a specification. Actually, one should consider, also, power imbalance because the eye can accommodate for slight changes in power, but a wearer cannot accommodate negatively in one eye and positively in the other at the same time, or he can't accommodate differentially between the two eyes.

TABLE 1

SAFETY GOGGLE FACE FORM ANGLE 3°

LENS A 6.00 Curve

Center Separation 60 mm.

Thickness 3.3 mm.

Power 0.00 Diopters

Wearer's P.D. →	54 mm.			60 mm.			66 mm.		
Angle of view to the right	0.1°	15°	30°	0.1°	15°	30°	0.1°	15°	30°
Eye to object distance 100 meters									
Left Eye T Power	0.00	0.02—	0.08—	0.00	0.02—	0.08—	0.00	0.03—	0.09—
Left Eye S Power	0.00	0.01—	0.03—	0.00	0.01—	0.04—	0.00	0.01—	0.03—
Right Eye T Power	0.00	0.01—	0.05—	0.00	0.01—	0.05—	0.00	0.01—	0.04—
Right Eye S Power	0.00	0.00	0.02—	0.00	0.00	0.02—	0.00	0.00	0.02—
Prism Imbalance	0.14—	0.14—	0.16—	0.14—	0.15—	0.19—	0.14—	0.16—	0.22—
T Magnification Imbalance	0.000	0.001—	0.001—	0.000	0.001—	0.002—	0.000	0.002—	0.004—
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Eye to object distance 1.0 meters									
Left Eye T Power	0.03—	0.05—	0.11—	0.03—	0.05—	0.12—	0.03—	0.06—	0.14—
Left Eye S Power	0.03—	0.04—	0.06—	0.03—	0.04—	0.06—	0.03—	0.04—	0.06—
Right Eye T Power	0.03—	0.03—	0.08—	0.03—	0.03—	0.07—	0.03—	0.03—	0.06—
Right Eye S Power	0.03—	0.03—	0.04—	0.03—	0.03—	0.04—	0.03—	0.03—	0.04—
Prism Imbalance	0.20—	0.21—	0.22—	0.21—	0.22—	0.26—	0.22—	0.24—	0.30—
T Magnification Imbalance	0.000	0.001—	0.002—	0.000	0.001—	0.003—	0.000	0.002—	0.004—
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Eye to object distance 0.43 meters									
Left Eye T Power	0.07—	0.10—	0.17—	0.07—	0.11—	0.19—	0.07—	0.11—	0.20—
Left Eye S Power	0.07—	0.08—	0.10—	0.07—	0.08—	0.11—	0.07—	0.08—	0.11—
Right Eye T Power	0.08—	0.07—	0.12—	0.08—	0.07—	0.11—	0.09—	0.07—	0.10—
Right Eye S Power	0.07—	0.07—	0.08—	0.08—	0.07—	0.08—	0.08—	0.07—	0.07—
Prism Imbalance	0.30—	0.30—	0.31—	0.32—	0.32—	0.36—	0.34—	0.35—	0.40—
T Magnification Imbalance	0.000	0.001—	0.002—	0.000	0.002—	0.003—	0.001—	0.002—	0.005—
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

There is another factor which hitherto has been ignored in specifications for plano lenses and shields, that is the factor of magnification. It is generally known in the ophthalmic professions that slight differences in meridional or over-all magnification between the two eyes, particularly differences in meridional magnification where the axes are oblique to each other between the two eyes, can cause serious difficulty.

The preparation of the data contained in this paper and the study of its significance was in connection with work done toward improving the design of safety goggles and various special purpose shields.

In addition to the conventional power, prism and astigmatic errors, we were also concerned with power imbalance between the two eyes, meridional magnification imbalances and the relationship between demand upon accommodation and convergence.

The data are the result of computations made on an IBM-650 electronic calculator. The program is designed to trace a ray from the center of rotation of a one eye position through to the object plane at whatever distance is chosen and also a ray from the other eye to the same point on the object plane. Both rays are then retraced, computing data as they go, on power, astigmatism, prism, prism imbalance, meridional magnification and magnification imbalance. The imput for the program consists of:

The wearer's P.D.
The vertex distance of the lenses or shield
The P.D. of the frame (or separation of the centers of the lenses)
The angle of view of the left eye to one side or the other,
(Always the right in our study)
The object distance (a flat plane normal to the straight ahead line of sight is assumed)
The curvatures and thicknesses of the lenses or shields
The face form angle if any.

In undertaking a broad survey of this kind in which there are several inter-dependent variables, one must be careful in selecting intervals and dimensions to vary; or such a voluminous amount of computing will be required that the project becomes over expensive and so much data is produced that the analysis becomes a formidable task.

In the safety goggle survey we, therefore, made rather wide choices in P.D. of frame and wearer and in object distance. Even then, with eight types of lenses, three wearers' P.D.'s, three frame P.D.'s and three object distances in order to obtain the information desired on each, would require the study of over eight thousand pieces of data. Therefore, we studied one lens completely to find in what situations the errors

TABLE 2

SAFETY GOGGLE FACE FORM ANGLE 3°

LENS A 6.00 Curve

Center Separation 74 mm.

Thickness 3.3 mm.

Power 0.00 Diopters

Wearer's P.D. →	64 mm.			74 mm.			80 mm.		
Angle of view to the right	0.1°	15°	30°	0.1°	15°	30°	0.1°	15°	30°
Eye to object distance 100 meters									
Left Eye T Power	0.00	0.02—	0.03—	0.00	0.02—	0.08—	0.00—	0.03—	0.10—
Left Eye S Power	0.00	0.01—	0.05—	0.00	0.01—	0.03—	0.00	0.01—	0.03—
Right Eye T Power	0.00	0.01—	0.02—	0.00	0.01—	0.05—	0.00	0.01—	0.04—
Right Eye S Power	0.00	0.00	0.02—	0.00	0.00	0.02—	0.00	0.00	0.02—
Prism Imbalance	0.14—	0.14—	0.16—	0.13—	0.15—	0.19—	0.14—	0.16—	0.22—
T Magnification Imbalance	0.000	0.000	0.001—	0.000	0.001—	0.002—	0.000	0.001—	0.004—
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Eye to object distance 1.0 meter									
Left Eye T Power	0.03—	0.05—	0.11—	0.03—	0.05—	0.12—	0.03—	0.06—	0.13—
Left Eye S Power	0.03—	0.04—	0.06—	0.03—	0.04—	0.06—	0.03—	0.04—	0.06—
Right Eye T Power	0.03—	0.03—	0.08—	0.03—	0.03—	0.07—	0.03—	0.03—	0.06—
Right Eye S Power	0.03—	0.03—	0.04—	0.03—	0.03—	0.04—	0.03—	0.03—	0.04—
Prism Imbalance	0.22—	0.22—	0.24—	0.23—	0.24—	0.27—	0.24—	0.25—	0.31—
T Magnification Imbalance	0.000	0.001—	0.002—	0.000	0.002—	0.000	0.000	0.002—	0.004—
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Eye to object distance 0.43 meters									
Left Eye T Power	0.07—	0.10—	0.17—	0.07—	0.11—	0.19—	0.07—	0.11—	0.20—
Left Eye S Power	0.07—	0.08—	0.11—	0.07—	0.08—	0.11—	0.07—	0.08—	0.11—
Right Eye T Power	0.08—	0.07—	0.10—	0.09—	0.07—	0.10—	0.09—	0.07—	0.09—
Right Eye S Power	0.08—	0.07—	0.08—	0.08—	0.07—	0.08—	0.08—	0.07—	0.08—
Prism Imbalance	0.34—	0.34—	0.35—	0.36—	0.36—	0.40—	0.38—	0.39—	0.44—
T Magnification Imbalance	0.000	0.001—	0.002—	0.001—	0.002—	0.004—	0.001—	0.002—	0.005—
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

were most serious and to what changes they were most sensitive. We confined the study of other lens types to these situations.

We found that there is very little difference in the performance of a given pair of lenses in a given frame with change in P.D. of the wearer. We also find that there is not a great deal of difference in the performance of a given pair of lenses in a given frame with the change in the bridge or eye size. However, those bridges and eye sizes which result in the greatest separation of the centers of the lenses create the worst conditions; therefore, to compare one product with another with a minimum of computing and analysis, if we assume the widest separation of the lenses, we can eliminate changes in the separations. That is why in this report the 74 mm. separation has more computing done on it than any others.

Because we found in the study of safety goggle lenses the changes in the P.D. of the wearer did not grossly affect the performance, we have eliminated changes in P.D. of the wearer in studying sun glasses. Similarly, we neglected changes in the P.D. of the frame. This greatly reduces the number of variables in studying what happens in the case of sun glasses.

We can conclude from the data presented in both cases, what lenses perform best under extreme conditions and that these lenses will be least sensitive to changes in conditions.

Face form angles were changed only for a few lenses to indicate the importance of considering face form angle and its effect on the various errors in a lens.

INTERPRETATION OF DATA

T — Power = Power in tangential meridian.
S — Power = Power in sagittal meridian.
Prism Imbalance = Horizontal prism imbalance (all angular data refers to the horizontal meridian.)
T Magnification Imbalance = Meridional magnification difference between the two eyes in tangential meridian.
S Magnification Imbalance = Similar information for sagittal meridian.
+ and — signs after power indicate positive and negative power.
+ Prism Imbalance = Base-in prism.
— Prism Imbalance = Base-out prism.

SAFETY GOGGLE DATA

Tables 1 and 2 contain data for a conventional safety goggle, 3.3

mm. thick, ground on a 6.00 diopter base curve, to measure zero power for an infinite object distance. The lenses are placed in a frame of 3° face form. Various combinations of frame P.D., wearer's P.D. object distance and angle of view to the right were computed. For simplification, only the extreme P.D.'s of the frame are listed. Table 1 shows data for a frame of P.D. 60 mm. and Table 2 shows data for a frame of P.D. 74 mm. It will be noted that in all cases, there is a measurable amount of prism imbalance for near objects. The power error exceeds the nominal value of the specifications for such lenses, yet these lenses would pass a telescope or lensometer test. On the other hand, it would be noted that for near objects, the accommodation-convergence relationship is not badly out of line, and it is for near objects that safety goggles are ordinarily used. Is this desirable or should power be reduced even if we can't reduce the prism at the same time?

It should also be noted that for wearers with wide pupillary distances, the meridional magnification becomes appreciable for wide fields of view. This may well be more worthy of attention than the more readily understood power errors, which, as can be seen, are appreciable and actually larger than in many prescription lenses.

TABLE 3
COMPARISON OF TWO SAFETY GOGGLE LENSES WITH DIFFERENT THICKNESS
FACE FORM ANGLE 3°

Right Hand Columns Lens C
Thickness 3.8 mm.—6.00 Base
0.00 Diopters
Center Separation 74 mm.
P.D. of Wearer → 68 mm.

Left Hand Columns Lens A
Thickness 3.3 mm.—6.00 Base
0.00 Diopters

	LENS A		LENS C	
Angle of view to the right	0.1°	30°	0.1°	30°
Object Distance 100 Meters				
Left Eye T Power	0.00	0.03—	0.00	0.09—
Left Eye S Power	0.00	0.05—	0.00	0.03—
Right Eye T Power	0.00	0.02—	0.00	0.06—
Right Eye S Power	0.00	0.02—	0.00	0.02—
Prism Imbalance	0.14—	0.16—	0.16—	0.18—
T Magnification Imbalance	0.000	0.001—	0.000	0.001—
S Magnification Imbalance	0.000	0.000	0.000	0.000
Object Distance 0.43 Meters				
Left Eye T Power	0.07—	0.17—	0.08—	0.20—
Left Eye S Power	0.07—	0.11—	0.08—	0.12—
Right Eye T Power	0.08—	0.10—	0.10—	0.12—
Right Eye S Power	0.08—	0.08—	0.09—	0.10—
Prism Imbalance	0.34—	0.35—	0.39—	0.40—
T Magnification Imbalance	0.000	0.002	0.000	0.003
S Magnification Imbalance	0.000	0.000	0.000	0.000

TABLE 4

COMPARISON OF TWO SAFETY LENSES WITH TWO BASE CURVES

Top Table—Lens C—6 Base, Thickness 3.8 mm.—0.00 Diopters Center Separation 74 mm.

Bottom Table—Lens D—9 Base, Thickness 3.8 mm.—0.00 Diopters Center Separation 74 mm.

Wearer's P.D. →	68 mm.		74 mm.		80 mm.	
Angle of view to the right	0.1°	30°	0.1°	30°	0.1°	30°
Eye to object 100 meters						
Left Eye T Power	0.00	0.09—	0.00	0.10—	0.00	0.10—
Left Eye S Power	0.00	0.03—	0.00	0.04—	0.00	0.04—
Right Eye T Power	0.00	0.06—	0.00	0.05—	0.00	0.05—
Right Eye S Power	0.00	0.02—	0.00	0.02—	0.00	0.02—
Prism Imbalance	0.16—	0.18—	0.16—	0.22—	0.16—	0.26—
T Magnification Imbalance	0.000	0.001	0.000	0.003	0.000	0.004
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.001
Eye to object 0.43 meters						
Left Eye T Power	0.08—	0.20—	0.08—	0.22—	0.09—	0.23—
Left Eye S Power	0.08—	0.12—	0.08—	0.12—	0.08—	0.13—
Right Eye T Power	0.10—	0.12—	0.10—	0.12—	0.11—	0.11—
Right Eye S Power	0.09—	0.10—	0.09—	0.09—	0.09—	0.09—
Prism Imbalance	0.39—	0.40—	0.41—	0.45—	0.44—	0.50—
T Magnification Imbalance	0.000	0.003	0.001	0.004	0.001	0.006
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000
Eye to object 100 meters						
Left Eye T Power	0.00	0.13—	0.00	0.16—	0.00	0.19—
Left Eye S Power	0.00	0.06—	0.00	0.06—	0.00	0.07—
Right Eye T Power	0.00	0.11—	0.00	0.09—	0.00	0.07—
Right Eye S Power	0.00	0.04—	0.00	0.04—	0.00	0.03—
Prism Imbalance	0.23—	0.22—	0.23—	0.29—	0.24—	0.35—
T Magnification Imbalance	0.000	0.000	0.000	0.003	0.000	0.005
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.001
Eye to object 0.43 meters						
Left Eye T Power	0.12—	0.28—	0.12—	0.32—	0.13—	0.35—
Left Eye S Power	0.12—	0.17—	0.12—	0.19—	0.12—	0.20—
Right Eye T Power	0.14—	0.19—	0.15—	0.17—	0.17—	0.15—
Right Eye S Power	0.13—	0.14—	0.13—	0.14—	0.14—	0.13—
Prism Imbalance	0.58—	0.53—	0.61—	0.61—	0.66—	0.69—
T Magnification Imbalance	0.000	0.001	0.001	0.003	0.001	0.005
S Magnification Imbalance	0.000	0.001	0.000	0.001	0.000	0.000

Table 3 compares two lenses with one P.D. for two object distances, indicating what happens when the thickness of a lens is increased even though the lens is corrected to give zero power for an infinite object distance. It can be seen that the lenses become more sensitive to changes in field of view and more sensitive to changes in object distance with an increase in thickness.

Table 4 serves two purposes. It compares two lenses of the same thickness with different base curves showing the difference in sensitivity of the design to object distance and to fields of view when the curves are changed even though they are compensated to give zero power for an

TABLE 5
SAFETY GOGGLE FACE FORM ANGLE 3°
LENS E 6.00 Curve
Center Separation 74 mm.
Thickness 3.3 mm.
Power +0.125 Diopters

½ Wearer's P.D. →	34 mm.		37 mm.		40 mm.	
Angle of view to the right	0.1°	30°	0.1°	30°	0.1°	30°
Eye to object distance 100 meters						
Left Eye T Power	0.12+	0.05+	0.12+	0.05+	0.13+	0.05+
Left Eye S Power	0.12+	0.09+	0.12+	0.09+	0.13+	0.09+
Right Eye T Power	0.12+	0.08+	0.12+	0.08+	0.13+	0.08+
Right Eye S Power	0.12+	0.10+	0.12+	0.10+	0.13+	0.10+
Prism Imbalance	0.21—	0.24—	0.14—	0.21—	0.06—	0.18—
T Magnification Imbalance	0.000	0.000	0.000	0.003	0.000	0.005
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.001
Eye to object distance 0.43 meters						
Left Eye T Power	0.05+	0.06—	0.05+	0.07—	0.05+	0.07—
Left Eye S Power	0.05+	0.01—	0.05+	0.01+	0.05+	0.01+
Right Eye T Power	0.04+	0.02+	0.04+	0.02+	0.04+	0.02+
Right Eye S Power	0.05+	0.04+	0.05+	0.04+	0.05+	0.04+
Prism Imbalance	0.47—	0.49—	0.42—	0.47—	0.37—	0.45—
T Magnification Imbalance	0.001—	0.003—	0.001—	0.005—	0.001—	0.006—
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000

infinite object distance. It also shows that with stronger curves and stronger thicknesses, lenses are more sensitive to changes in P.D. of the wearer for a given frame. This is of particular interest in recommending safety goggles since usually safety goggles are fit for mechanical comfort and the P.D. of the frame does not.

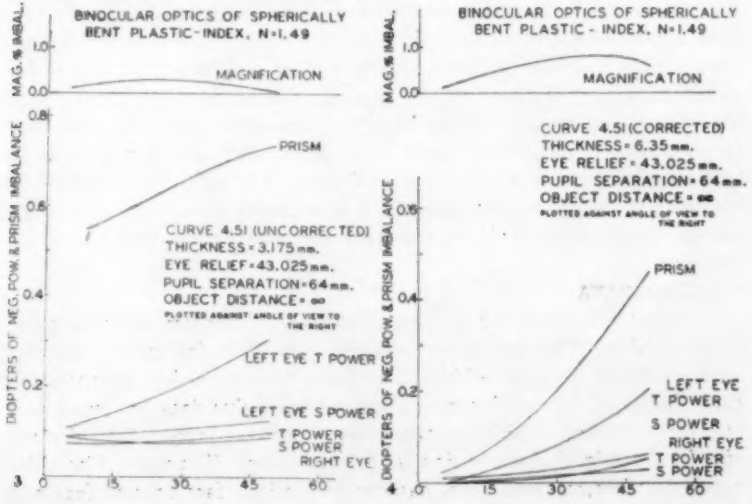


TABLE 6
SAFETY GOGGLE THREE FACE FORM ANGLES
LENS F — 9.00 Curve
Center Separation 74 mm.
Thickness 3.8 mm.
Power +0.125 Diopters

P.D. of Wearer 74 mm.	Face Form —3°		No Face Form		Face Form 6°	
Angle of view to the right	0.1°	30°	0.1°	30°	0.1°	30°
Eye to object distance 0.43 meters						
Left Eye T Power	0.02+	0.08—	0.02+	0.12—	0.01+	0.22—
Left Eye S Power	0.02+	0.02—	0.02+	0.03—	0.02+	0.06—
Right Eye T Power	0.02+	0.09—	0.00—	0.05—	0.03—	0.01—
Right Eye S Power	0.02+	0.02—	0.01+	0.01—	0.00	0.01—
Prism Imbalance	0.18—	0.09—	0.39—	0.35—	0.81—	0.85—
T Magnification Imbalance	0.000	0.001	0.000	0.002	0.001	0.006
S Magnification Imbalance	0.000	0.000	0.000	0.001	0.000	0.001

Table 5 contains data on a lens which has been compensated to give substantially zero power for a very near object distance for which many safety goggles are used. Such a lens would not pass most specifications, requiring that they be tested with a telescope. The logical solution to this problem would be to compromise and correct part way between infinity and the nearest distance for which the lens is expected to be used. Even then, however, the designed errors in the lenses would make them borderline according to most specifications, and any slight shift toward the plus in the production technique would indicate that they would fail conventional specifications.

Table 6 shows data illustrating what happens when the face form angle is changed. Data for an anti-face form angle of 3° for no face form angle and for an angle of 6° is given for a 9.00 curve lens 3.8 mm. thick. This lens was designed to give 1/8 of a diopter plus power for an infinite object distance. It can be seen with an anti-face form angle, the power and prism relationships are reasonably good for the near object distance. However, for a long object distance there would be base-in prism which would be undesirable. The figure is presented to illustrate the effect on the errors in a lens caused by a face form angle change, this further indicates the need for compromise between object distances.

SUNGLASS DATA

Table 7 summarizes data regarding a 6.00 diopter curve sunglass, 2 mm. thick. The first three columns give data for lenses mounted squarely before the eyes, with no face form, for two object distances and three angles of view. The next three columns give data for lenses in a face formed frame which have been decentered to correct the prismatic effect for straight ahead vision and long object distances. The third group of three columns gives data on lenses in a face formed frame in

TABLE 7

SUN GLASS FACE FORM
6 BASE GROUND AND POLISHED

P.D. of Frame 64 mm.
P.D. of Wearer 64 mm.

	No Face Form No Decentration			10° Face Form With Decentration			10° Face Form No Decentration		
Angle of view to the right	0.1°	15°	30°	0.1°	15°	30°	0.1°	15°	30°
Eye To Object 100 meters									
Left Eye T Power	0.00	0.01—	0.04—	0.00	0.02—	0.07—	0.01—	0.03—	0.09—
Left Eye S Power	0.00	0.00	0.02—	0.00	0.01—	0.02—	0.00	0.01—	0.03—
Right Eye T Power	0.00	0.01—	0.04—	0.00	0.00	0.02—	0.01—	0.00	0.01—
Right Eye S Power	0.00	0.00	0.02—	0.00	0.00	0.01—	0.00—	0.00	0.01—
Prism Imbalance	0.00	0.00	0.00	0.00	0.03—	0.11—	0.28—	0.31—	0.39—
T Magnification Imbalance	0.000	0.000	0.000	0.000	0.002	0.005	0.000	0.003	0.005
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Eye To Object 1 meter									
Left Eye T Power	0.02—	0.03—	0.06—	0.02—	0.04—	0.10—	0.02—	0.06—	0.12—
Left Eye S Power	0.02—	0.02—	0.03—	0.02—	0.02—	0.04—	0.02—	0.03—	0.05—
Right Eye T Power	0.02—	0.02—	0.05—	0.02—	0.02—	0.03—	0.03—	0.02—	0.03—
Right Eye S Power	0.02—	0.02—	0.03—	0.02—	0.02—	0.02—	0.02—	0.02—	0.02—
Prism Imbalance	0.05—	0.05—	0.05—	0.05—	0.07—	0.15—	0.33—	0.35—	0.43—
T Magnification Imbalance	0.000	0.000	0.000	0.000	0.002	0.005	0.000	0.002	0.005
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

which the lenses have not been decentered to correct the prism. Table 8 has analogous data for a 4.00 diopter curve, dropped or bent lenses. It must be remembered that such lenses usually do not hold their curves at off-center points, so this data does not give as true a picture as was the case with the ground and polished lenses.

With sun glasses also, we come to a question of tolerances. In Table 7, we note that there is prism imbalance in the third case, with little power error. In Table 8, we note negative power as well. Is this to be desired or not? The accommodation convergence relationship is better, yet, according to present standards, the second type would be a less desirable product.

Figure 3 is a set of graphs showing the errors present in a one-piece bent plastic shield. The curvature + 4.50 D. is approximately as flat as is practical in a one-piece face shield. Steeper curves would have larger errors, flatter less, as will be seen later. The data are given for a sphere although most such shields are cylindrical. To obtain errors for a cylindrical shape, assume the sagittal values to be zero. Errors are plotted against angle of view.

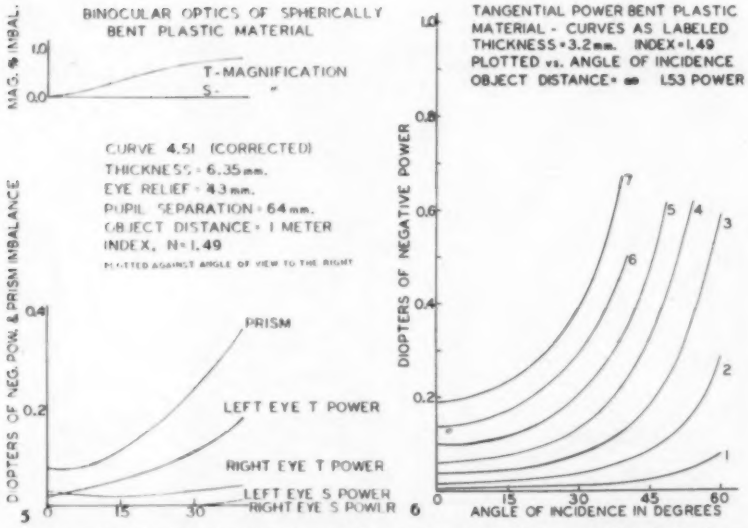
Figure 4 contains similar information for a cast or molded shield with compensated curves of similar general shape. Note that in Figure 4, in the corrected shield, the meridional magnification imbalance is worse than in the uncorrected shield, Figure 3, this is because the shape magnification of Figure 3 is compensated for by its negative power acting through the distance to the eyes.

Figure 5 contains information for the same shield as Figure 4 but for an object distance of one meter. It is again worth noting that in the case of the uncorrected visors although both base-out prism and negative power are greater than in the corrected type, the accommodation convergence relationship is superior.

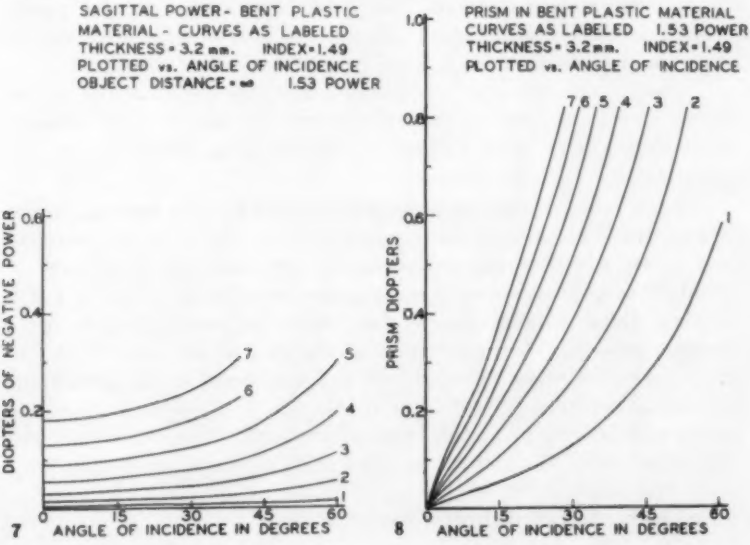
ANGLE OF INCIDENCE DATA

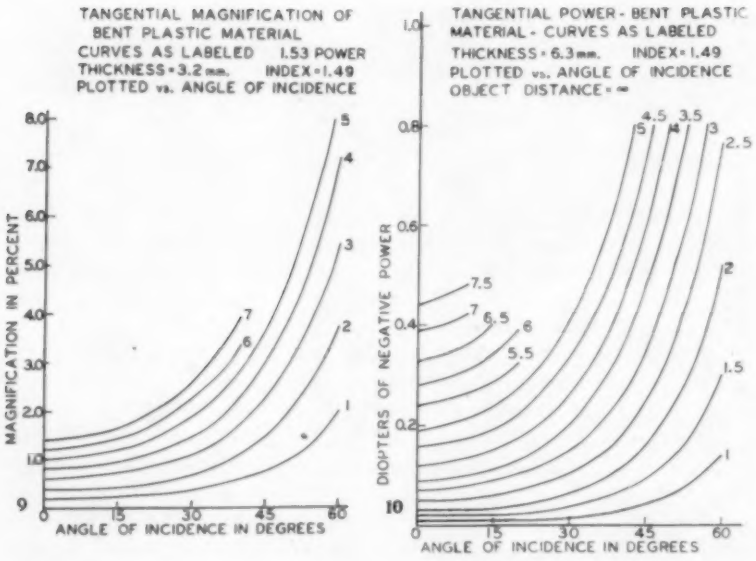
In order to understand the basic phenomena behind the performance of bent lenses and shields and to obtain a clear picture of their possibilities and limitations, we studied the aberrations of the material itself for various thicknesses without respect to eye position except to vary the angle at which the line of sight strikes the material (angle or incidence). The various errors introduced by these conditions are shown in Figures 6 through 12. The figures are self explanatory.

These graphs serve as a guide in determining the possibilities of good design with various curves and thicknesses. In an actual design situation the total prism for a given point of view is not of as much importance as the imbalance between the two eyes. The magnification



of a lens itself often has little meaning unless the distance behind the lens is taken into account because any residual power in the lens will create additional magnification which depending on its sign add to or subtract




TANGENTIAL MAGNIFICATION OF BENT PLASTIC MATERIAL
CURVES AS LABELED 1.53 POWER
THICKNESS = 3.2 mm. INDEX = 1.49
PLOTTED vs. ANGLE OF INCIDENCE
MAGNIFICATION IN PERCENT
ANGLE OF INCIDENCE IN DEGREES
9
TANGENTIAL POWER - BENT PLASTIC MATERIAL - CURVES AS LABELED
THICKNESS = 6.3 mm. INDEX = 1.49
PLOTTED vs. ANGLE OF INCIDENCE
OBJECT DISTANCE = ∞
DIOPTERS OF NEGATIVE POWER
ANGLE OF INCIDENCE IN DEGREES
10

from the magnification created by the lens. In general, with bent plastic shields magnification errors are not gross because the negative power creates a negative magnification, whereas the bent material itself creates a positive magnification and frequently the two tend to cancel out.

This is not the case with some "corrected" shields and lenses, where for oblique fields of view plus power for one eye and negative power for the other create a significant magnification difference.

CONCLUSION

These tables of data are presented not to prove that some particular type of lens is better than another but to show that in many instances some lenses which would at first seem to be relatively error free, do indeed, have as gross errors as many prescription lenses. This is worth thinking about because prescription lenses are supplied under professional guidance. The possibility of the patient having difficulty in adjusting to his lenses is recognized and considered in the prescribing and fitting. Frequently very little of this type of attention is given the process of supplying protective lenses of any kind. The wearer may just buy them across the counter, or they may be forced upon him by a safety engineer.

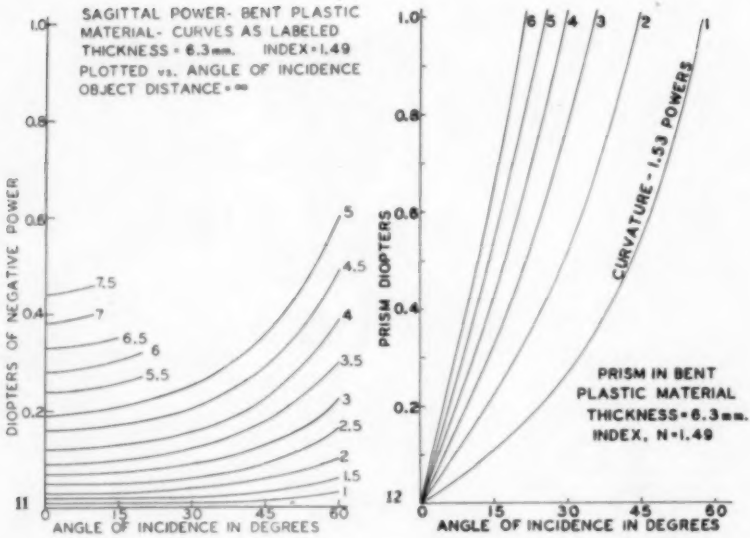
The purpose of this paper has been:

TABLE 8

SUN GLASS FACE FORM
4 BASE DROPPED LENS

P.D. of Frame 64 mm.
P.D. of Wearer 64 mm.

	No Face Form No Decentration			10° Face Form With Decentration			10° Face Form No Decentration		
Angle of view to the right	0.1°	15°	30°	0.1°	15°	30°	0.1°	15°	30°
Eye to Object 100 meters									
Left Eye T Power	0.04—	0.05—	0.07—	0.04—	0.05—	0.08—	0.04—	0.06—	0.10—
Left Eye S Power	0.04—	0.04—	0.05—	0.04—	0.04—	0.05—	0.04—	0.05—	0.06—
Right Eye T Power	0.04—	0.05—	0.07—	0.04—	0.04—	0.06—	0.04—	0.04—	0.05—
Right Eye S Power	0.04—	0.04—	0.05—	0.04—	0.04—	0.04—	0.04—	0.04—	0.04—
Prism Imbalance	0.00	0.00	0.00	0.08—	0.09—	0.12—	0.19—	0.20—	0.26—
T Magnification Imbalance	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.002	0.003
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Eye to Object 1 meter									
Left Eye T Power	0.05—	0.06—	0.08—	0.05—	0.06—	0.10—	0.06—	0.08—	0.12—
Left Eye S Power	0.05—	0.05—	0.06—	0.05—	0.06—	0.06—	0.05—	0.06—	0.07—
Right Eye T Power	0.05—	0.06—	0.07—	0.05—	0.05—	0.07—	0.06—	0.05—	0.06—
Right Eye S Power	0.05—	0.05—	0.06—	0.05—	0.05—	0.06—	0.05—	0.05—	0.05—
Prism Imbalance	0.03—	0.03—	0.03—	0.11—	0.12—	0.14—	0.21—	0.23—	0.28—
T Magnification Imbalance	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.002	0.004
S Magnification Imbalance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000



To present data on the optical characteristics of plano lenses of interest to optometrists.

To discuss the aspects of design of such lenses which aggravate or reduce undesirable characteristics.

To stimulate thinking and discussion among interested persons toward more comprehensive and more pertinent specifications for protective lenses and shields.

To point up the need for gathering together and applying the results of research which pertain to questions regarding specifications and tolerances for plano lenses.

ANNOUNCEMENT

WRITE FOR ACADEMY POST-GRADUATE COURSE PROGRAM

Optometrists who are thinking of attending the annual Post-Graduate Courses of the American Academy of Optometry, December 4-6, The Drake Hotel, Chicago, are invited to write and request a free 12 page program which reviews all 52 courses. Requests should be sent to the American Academy of Optometry, 1506 - 1508 Foshay Tower, Minneapolis 2, Minnesota. All optometrists are invited to attend these courses.

COMMENTS ON FAULTY COLOR DISCRIMINATION*

Israel Dvorine†
Baltimore, Maryland

Although it is not generally realized, especially among the lay public, a study of color-blindness involves five basic sciences—physics, physiology, chemistry, psychology and philosophy.[1] The act of color perception depends upon a number of factors and a number of approaches. For example, when we discuss the properties of light and its electro-magnetic radiations, or when we discuss the spectrum, we are speaking of aspects of the physical world, matters which are of special interest to the physicist. When we speak of the human eye, and such things as retinal receptors, optic nerves, optic radiations and visual cortex, we are concerning ourselves with the field of physiology. The problem of the conversion of radiant energy to neural energy is one for the chemist to solve. Finally, when we discuss the causes of color-blindness, we can scarcely do so except in terms and concepts from the field of philosophy and psychology. This is clear when we reflect that the experience of color is a sensation, involving perception, identification, and recall, and for a full understanding of this experience we must turn to the realm of psychology.

When you see a red rose, the chances are that you think of the color as being an attribute of the blossom itself. Most people do. The physicist, however, knows that color depends on the light reflected from the flower. He calls the reflected light red. The physiologist knows that while the rose appears red to you when you look at it directly, it may appear yellow or gray if you view it at such an angle that its image falls upon the periphery of your retina. He therefore thinks of the color, not as an attribute of the flower, or even as a result of the characteristic properties of the light, but rather as an attribute of the eye itself. Or, to express it more specifically, he thinks of the color as the result of stimulation of the retinal receptors. Finally, the psychologist sees the red not as an attribute of the flower, or of the light, or of the eye, because he feels that color perception is a psychic phenomenon. That is, he thinks of color as a definite qualitative entity in consciousness which depends for its identification on the individual's differential experience.

*Submitted on May 27, 1957, for publication in the October, 1957, issue of the AMERICAN JOURNAL OF OPTOMETRY AND ARCHIVES OF AMERICAN ACADEMY OF OPTOMETRY.
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If one is to have a full understanding of color vision, one must keep these various points of view in mind. It is important to remember the complexity of the phenomenon, and to realize that full understanding of it cannot be achieved without taking into consideration all of the physical, physiological, and psychological aspects of the problem.[2]

When white light is broken up by passing through a prism, or by a diffraction grating, the normal observer sees a number of colored bands ranging from red to violet. This is known as the solar spectrum. The refraction, or the dispersal of a beam of white light into a bundle of colored beams differently refracted is a consequence of the fact that the index of refraction of a material is not the same for all colors, but is greater for the short wave lengths than for the long ones. Thus, when a beam of white light passes obliquely from air to glass, the violet rays deviate the most toward the normal, and the red rays deviate the least.[3] We may describe the spectrum in a somewhat different manner by saying that it is the pattern of refracted (and therefore colored) light bands produced in the order of their wave lengths.[4]

The observer with normal color vision responds to the stimulation of the various frequencies of the visible spectrum. The color-blind individual is one whose visual process is capable of only a limited response to chromatic stimulation. Thus, he does not respond to the stimulation of the various frequencies of the visible spectrum to the same extent, or in the same manner as does the normal observer.[5]

From the point of view of subjective color sensation, it is important to understand the qualitative elements that are common to all colors. These elements are hue, saturation, and brightness. Hue is the quality by which the different colors of ordinary parlance are distinguished. That is, it is hue that enables us to distinguish between green and red, yellow and blue. Saturation is the amount of pure spectrum color present. That is, if the color is mixed with white or with any other color, it becomes less saturated. We may express this a little differently by saying that saturation is the relative differentiation of any color sensation from the sensation of gray or white. Thus it follows that delicate diluted tints, or pastel colors, as for example, flesh tones, are relatively unsaturated, while the stronger and more vivid colors, such as ruby red or emerald green, are relatively saturated.[6]

Brightness is the luminosity of the color. It is that qualitative element in color which differentiates light reflected from a surface illuminated by a 100 watt lamp from that light which is reflected when the surface is illuminated by a 300 watt lamp. Brightness is actually a subjective quality, and it varies not only with the intensity of the color,

but also with the sensitivity of the individual observer. In general, brightness increases from red to the middle of the spectrum, and decreases again towards the violet. If the illumination or brightness value is increased beyond a certain limit, all of the hues become white. On the other hand, if it is reduced beyond a certain limit, the hues become all black. We have all had the experience of losing the capacity to distinguish color in the dark, as well as that of losing it in a light that is too bright and blinding.[7]

It may be helpful in understanding the phenomenon of color experience to realize that the hue, saturation and brightness of color have close analogues in the pitch, timbre, and loudness of sound. However, there is one important difference. The human ear is an analytical instrument. That is, it can distinguish individually all the frequencies that reach it simultaneously. The human eye, however, lacks this analytical capacity, for it perceives and records but a single hue. For example, if a red and green light are projected on a surface and the resultant mixture of light is reflected towards the eye, the subjective sensation experienced by the individual is that of a yellow light.[8]

The color sensations that light produces, like all of its other properties, depend primarily upon its wave length. The wave length of visible light is measured in millimicrons. In the visible spectrum, these lengths range from 380 mμ. to 760 mμ., from the shortest violet to the extreme visible red.[9]

The difference between the color-blind or color-weak individual, and the normal individual is that the latter responds to all of the wave lengths of visual light, from 380 to 760 mμ., while the color-blind individual is insensitive to some or all of them. In other words, the visual perception of the color-blind person is such that he does not perceive the gradations of color from violet to red. His spectrum is broken up by one, and sometimes more "neutral areas," in which he does not observe any color at all, but sees only a band of gray, or he may see gradations of the same color, where the average observer will see different colors. For example, what looks like a band of red color to the average, or normal observer, may appear as yellow or green to the color-blind or color-weak individual. His sensation, of course, will depend upon the type and degree of defect from which he suffers.[10]

The color-blind individuals are generally classified as monochromats and dichromats. The monochromat is a totally color-blind individual who lacks the ability to perceive even one color in the spectrum. His visual world consists of gradations of white and black of varying brightnesses. There are two types of monochromats and they can be identified by their ocular symptoms.

Type one, known as the rod-monochromat, has good twilight vision but very defective day vision. Nystagmus and photophobia are frequently present.

Type two has normal visual acuity with good light and dark adaptation. Because he possesses good photopic and scotopic vision, this type is called the rod-cone monochromat. The luminosity function of both types is below normal, at 510 mμ. instead of 555 mμ. Totally color-blind individuals are extremely rare.

The dichromat differs from the normal individual by being able to match all colors of the spectrum with a mixture of two colors only, while the normal, or trichromat, requires a mixture of three colors to make a good match. There are three major types of dichromatism: Protanopia, deuteranopia and tritanopia.

Protanopia, also known as the red-blind type, is a form of red-green insensitivity whose distinctive feature is a shortening of the long-wave end of the visible spectrum. Most of these individuals cannot perceive any color beyond 680 mμ., but since they are sensitive to some red waves, the term red-blindness is only partially true. The luminosity function of the protanope is shifted toward the short-wave end, with the maximum being close to 540 mμ. The main color confusions are between the reds, dark brown, and blacks and between greens and fawns. Purples and magentas tend to be confused with pale blue.

Deuteranopia, also known as green-blindness, is actually a form of complete red-green blindness. The deuteranope sees two neutral bands in the spectrum, one close to 497 mμ., where the normal eye sees bluish-green and the other where the normal sees red-purple. The maximum luminosity function of the deuteranope approximates that of the normal individual, being at 560 mμ. The main color confusions are between the reds, oranges and greens, while magentas and purples tend to look gray.

Tritanopia, or blue-yellow blindness, resembles protanopia in one respect, the tritanope also has a shortened spectrum; except that in the former the long-waves are shortened while in the latter it is the short-waves. The neutral point in the spectrum is at 572 mμ., and the luminosity function is close to normal, at 560 mμ. With violet and yellow lacking, the tritanope should see reds on the long wave side of his "yellow" neutral point and green on the other side of it.[11]

Pickford believes that this third classification is superfluous, and that all color-blind individuals can be accurately classified as either protanopes or deuteranopes.[12]

Color-blindness is usually inherited, although there are cases, in

old age, in which it has been acquired. Among the causes of acquired color-blindness may be mentioned accidents, the use of narcotics, psychological disturbances, and the effects of disease.[13] At least one authority, Pickford, raises the question of a possible hereditary predisposition to acquired color-blindness.[14]

Congenital color-blindness is a partially sex linked Mendelian recessive trait. It is transmitted by the sex chromosomes, XY in the males, and XX in the females. The defect is transmitted by the X chromosomes. In males, only one X chromosome has to be affected to cause color-blindness, but in females, both X chromosomes must be affected for the defect to appear. This is the reason why there are fewer color-blind females than males.[15]

From a physiological point of view, any one of a number of factors may be present in a case of color-blindness. For example, the amount of pigment in the eye may effect the color vision of an individual, causing him to see colors differently from the way in which the average, or normal viewer perceives them. Again, the sensitiveness of the receptors to particular wave lengths may be abnormal. Under different light adaptation, the *ph* of the visual purple changes, and this may cause a change in the absorption of some particular wave length. In one or more types, the receptors may be present in abnormal numbers. The retina may lack the usual number of cones essential for the perception of color. Again, there may be faulty neural connections between the retina and the optic nerve, or lesions in the optic pathways or in the cerebral cortex. Or the color-blindness may be due to an arrested development in the visual process. All of these physiological conditions have been found in various cases of color-blindness, and this is an indication of the complexity of the condition.[16]

Why do color-blind people constitute a problem of real magnitude and importance? Primarily because color-blindness makes those afflicted by it unfit for certain work. The chief element of tragedy in this situation, however, is not the color-blindness itself, but the fact that so many of those who suffer from this defect are themselves unaware of it. Many adjustments are possible to the condition of color-blindness, but if one is unconscious of the condition, he cannot make those adjustments, and the failure to do so can lead to much wasted effort, needless worry, and even accidents and misfortune.

An example will illustrate this point. One might, at first thought, find it difficult to recognize the sheet metal industry as one in which good color judgment is essential. Yet one sheet metal printer lost the time and material for more than 780,000 talcum cans because of a mis-

take in color.[17] Indeed, there is hardly a vocation or profession today which does not require some color discrimination on the part of the individual. The doctor, the chemical engineer, the driver of a vehicle, even the filing clerk who handles index cards of different colors—all need good color discrimination. When we realize that approximately one out of every ten men has defective color vision, the magnitude of the problem becomes evident.[18]

It is true that once color-blindness is recognized, adaptations are, in the majority of cases, quite possible, so that the life and usefulness of the individual need not necessarily be upset. This, however, in no way destroys the validity of the point that testing, selection and classification of the color-blind on a large scale, and at the earliest possible date, preferably early in school, is a necessary procedure.

There are a number of tests that can be given to discover color-blindness. Generally speaking, these tests may be divided into four classes. The first of these includes the simple screening tests, designed to do nothing more than to separate the color-blind from those with normal color vision. The second class includes those qualitative diagnostic tests that have been planned to classify the color-blind according to the particular type of defective color vision from which the individual in question is suffering. The third type of test is also diagnostic in character, but it is quantitative rather than qualitative. It is designed to indicate the exact degree of the weakness or defect manifested by the subject. Finally, there are a number of color aptitude tests which aid in determining the fitness of the subject for some particular task.[19]

The problem is not the identification of the color-blind, for the testing techniques are simple with pseudo-isochromatic plates.[20] Rather, it is to convince the public that testing for color-blindness is an essential part of education, so that public opinion will demand that all children be tested for color-blindness at an early age.[21]

Aside from the individual worry, inconvenience and suffering that would thereby be prevented, there are other ways in which the public would benefit from such a procedure. The identification of all of the color-blind in the population would have the effect of immediately opening up new paths and possibilities for further research into the problem. It would result in the perfecting and improving of the tests that have already been designed, and in the creation of new tests for special cases. It would bring about improvements in the methodology of test preparation. For example, it is known that much testing for color-blindness has been futile and a waste of time, due to the fact that some operators have, through ignorance or carelessness, permitted varia-

tion in the illuminant used in the test. Yet precision in this respect is an essential factor in the accuracy of any test for color-blindness that involves reflected light.[20]

Compulsory testing for color-blindness in the early years of school would also undoubtedly open up many new paths for research in the area of corrective and remedial measures. This is a field of study in which comparatively little has been accomplished to date, although a few have attempted to improve individuals with weak color discrimination through training and exercises.[21, 22] What success was attained with these individuals may have been due, however, to the possibility that these color-weak people learned to utilize other factors of discrimination to compensate for their deficiency. Positive identification of all the color-blind in the population would act as a marked stimulus for further research in remedial procedures.

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SHEARD VOLUME OUT IN OCTOBER

The long awaited Sheard Volume will come off the presses and be available some time during October. The 600 optometrists, opthalmologists and opticians who sponsored the volume will receive their copies direct from the publisher, the Chilton Company, Chestnut at 56th St., Philadelphia. Others may purchase the book by sending their orders direct to the Chilton Company. The cost of the book will be $15 and all royalties on the sale of the book will go for research in visual sciences at the Ohio State University, Columbus.

The book contains a selection of significant writings of Dr. Charles Sheard. These essays and technical papers were selected by the sponsoring committee from among 300 titles that were available and which had enriched the literature during the past 40 years. The selection of material included in the Sheard Volume was a most interesting task as the committee seriously considered a great number of his papers, all of lasting importance, and of sufficient quantity to fill three volumes, each of

more than 450 pages. As funds were available for only one volume, considerable time was taken in making the final selection and it is anticipated that readers of this book will heartily approve their work.

Many of the papers which are included, originally appeared in the AMERICAN JOURNAL OF PHYSIOLOGICAL OPTICS which was published quarterly, for a six year period, by the American Optical Company and edited by Dr. Sheard. It was during this period, right after World War I, that Dr. Sheard brought to the science of refracting the acceptable viewpoints of today, dealing with dynamic skiametry, the accommodative-convergence relationships, the importance of near-point findings and his 17-point refractive routine.[1] These early papers are now out of print and this was one of the reasons for having the volume published.

Another reason was that Dr. Charles Sheard held a very unique place among educators in ophthalmic optics. He started one of today's fine undergraduate schools in optometry[2] and later was Dean of another.[3] For a long period of time he was a member of the faculty of a graduate school in medicine and for years taught physiological optics to physicians holding fellowships in ophthalmology.[4] At another point in his fruitful career, he started and taught a course in opticianry,[5] and today, while in retirement, is still active as a visiting lecturer in physiological optics during the winter months in the South.[6] For his contributions to education in the field of visual science Dr. Sheard is held in high regard throughout optometry, ophthalmology and opticianry.

Dr. Charles Sheard is a physicist. He received his Ph.D. degree early in the century when physicists could devote their energies to peaceful activities. He came into ocular refraction just at the right time. His arrival was fortunate as his contributions to the educational processes in the visual sciences everywhere advanced the training of clinical practitioners and has made their work of infinitely greater value to the public they serve.

During his interesting career, the author of the many papers in the Sheard Volume has received a number of honors in the fields in which he has worked. He is an honorary life member of the American Academy of Optometry, the American Academy of Ophthalmology and Otolaryngology, the American Optometric Association and is a founder

[1]This is the basis for the present 21-point routine of the Optometric Extension Program.
[2]School of Optometry, The Ohio State University, Columbus.
[3]Los Angeles College of Optometry, Los Angeles.
[4]University of Minnesota, Mayo Foundation, Rochester, Minnesota.
[5]Rochester Minnesota Junior College.
[6]Department of Ophthalmology, Tulane University, New Orleans.

and patron of the American Board of Opticianry, to mention but a few. He has given the Thomas Young Oration in England and has received a citation for his military research work from his country.

This book is a joint effort on the part of friends of Dr. Charles Sheard in the United States, Canada and England. More than 600 sponsors made advance contributions to make the book possible. The names of these sponsors appear at the end of the book. The committee for the Sheard Volume was drawn from optometry, ophthalmology and opticianry. Dr. Meredith W. Morgan, Jr., School of Optometry, University of California, Berkeley, acted as chairman of the project and headed the optometric section of the committee. Dr. William Benedict, secretary, A.A.O.O., Rochester, headed the ophthalmologists division, and Leslie W. Myers, N. P. Benson Optical Company, Minneapolis, headed the opticianry division. The support these committees received was wholehearted.

After looking over the advance page proofs, the writer believes this book will find a welcome in the hands of many optometrists. These readers will find the material most enjoyable and in addition to the historical value of the book, many younger readers will also discover the scientific backgrounds upon which are based today's refractive tests. The book is well prepared and the sponsoring committee is indebted to Dr. Monroe J. Hirsch, Ojai, California, and to Dr. Charles Sheard for reading the proofs.

The Sheard Volume is a non-profit venture. The committee that made the book possible receives the satisfaction of a job well done. The Chilton Company* has relinquished their usual profit and the author receives no royalties. All income over production and sales costs will revert to a fund at the Ohio State University, which will be used for financing research work in vision. The distribution of the Sheard Volume brings to a close a fine example of interprofessional relationships working towards the common goal of better education, science and clinical practice. The American Academy of Optometry has already supported this project in an excellent manner as nearly half of the sponsors are its members. Let us now hope the new Sheard Volume enjoys the wide sale it richly deserves.

CAREL C. KOCH

*The Chilton Company is best known to optometrists as the publishers of the OPTICAL JOURNAL AND REVIEW OF OPTOMETRY.

SPECIAL REPORTS

DEMAND AND SUPPLY OF OPTOMETRY TEACHERS IN THE NEXT DECADE*

Henry W. Hofstetter†
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INTRODUCTION

During the last decade or two the faculty members of the optometry schools have been recruited from three primary groups, as follows:

a. Selected graduates of optometry curricula without further academic qualification.
b. Specially qualified persons from adjacent or related fields (e.g., degree holders in anatomy, physics, physiology, psychology, education, and medicine).
c. Graduates of optometry curricula with special additional qualifications leading to an M.S. or Ph.D. degree, or the equivalent, in physiological optics, visual psychology or similar programs.

In general, the "a" group is a high turnover group from the contemporarily graduating students and probably presents no critical problem of supply and demand in any given year or decade except that during the next decade the increased shortage of practicing optometrists may make it more difficult to hold superior graduates for a year or more for teaching purposes.

The supply in the "b" group can be expected to dwindle very rapidly beginning about 1960 when the "war babies" start to swell enrollment in all of the colleges of the country. There is of course very little that optometry schools can do to insure a supply of personnel in this category, though much of the teaching and research now being carried on by persons of this background could be carried on effectively by those in group "c," if the supply of that group is ample.

The supply in the "c" group reflects the number and accessibility of institutions offering specialized programs for this type of training.

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This is a report on a survey made while the author was president of the Association of Schools and Colleges in Optometry.
†Optometrist. Ph.D., Director of College. Fellow, American Academy of Optometry.

the number of current optometry graduates serving as a pool from which superior recruits may be selected, the financial aid available to students pursuing the additional years toward an M.S. or Ph.D. degree, and, of course, the attractions of the fields of teaching and research open to them.

AVAILABLE ESTIMATES, FACTS, AND FIGURES

A poll of the executive heads of 12 schools and colleges of optometry in the U. S. and Canada was made to determine their individual estimates of the number of new full-time, or full-time equivalent, members of their respective faculties or academic administrations they would expect to replace or add in the 10-year period 1960-1970, either for expansion or normal replacement purposes. In addition, each respondent was asked to state "(1) how many of these should have completed only the professional optometry program, (2) how many should have at least one additional year of specialized training in education and research in the visual sciences as represented in an M.S. or equivalent degree, and (3) how many should have similar additional training to the Ph.D. level or equivalent." The results of the inquiry are shown in Table I.

TABLE I

Number of faculty replacements and additions anticipated in the 10-year period 1960-1970 in the 12 optometry schools of the U. S. and Canada. (*Estimate not supplied by the school—hence computed as average of the other 11.)

School	Optometry graduates	M.S. or equivalent	Ph.D. or equivalent
a	4	2	2
b	1	0	1
c	2 to 4	1	1
d	15	5	4
e	2 to 3	1 to 2	2 to 3
f	0	4	1
g	7	1	1
h	8	3	2
i	6*	2*	3*
j	6	0	4
k	20	2	5
l	4	4	2
Total	75–78	25–26	28–29

In order to evaluate the effectiveness of the present sources of supply of M.S. and Ph.D. degree holders in meeting the teaching needs, the three universities with fully operating programs in physiological optics leading to both degrees were submitted an inquiry relative to the careers now being pursued by their past M.S. and Ph.D. earners. The results are shown in Table II.

TABLE II

Activities of M.S. and Ph.D. degree holders from three universities offering graduate programs in physiological optics.
(*9 of these also hold the M.S. degree and are not included in the M.S. column.)

Primarily engaged in:	M.S. degree only	Ph.D. degree
Optometric education	5	10
Vision research	4	3
Private practice	3	0
Military optometry	6	0
Other	1	0
Total	19	13*

If the proportions represented by the figures in Table II are used as a guide, it may be estimated that only 10/13th of the Ph.D. degree earners, and only 5/19th of the M.S. degree earners may be expected to use their training in the service of optometric education. Hence to meet the anticipated need for 28 to 29 Ph.D. degree holders in optometric education it would be necessary to produce $28.5 \times 13/10$ or 37 Ph.D. degree holders. To meet the anticipated need for 25 to 26 M.S. degree holders it would be necessary to produce $25.5 \times 19/5$ or 97 M.S. degree holders. Since about two-thirds of the Ph.D. earners include the acquisition of the M.S. degree as intermediate steps in their programs, an estimated 25 should be added to the 97, making 122 M.S. degrees and 37 Ph.D. degrees that would have to be granted during the next 10 years to meet the predicted optometric education demands of the next decade.

INCIDENTAL FACTORS

Whether or not this is a conservative evaluation is of course a matter of opinion, though the author feels that the estimates given by the 12 respondents were highly conservative, that their comments typically suggested an attitude of counting only the replacements and additions that they could foresee quite clearly.

Other factors not taken into account in the evaluation of these estimates include:

(1) The relatively small number of optometry graduates anticipated for the period 1957-1967, from which group the needed graduate students must be selected and attracted. (The "war babies" will not begin to graduate from optometry until about 1966.)

(2) The lack of sufficient optometry graduates for professional replacement and population expansion during the same period, making the attractions of private practice a much greater source of competition than it was during the past 10 years.

(3) The apparently increasing opportunities for graduate degree holders in non-educational areas, such as in military optometry, research laboratories, and industry, all acting to attract the graduate degree earners away from careers in optometric education.

(5) The always present possibility that the new decade will create new optometry schools demanding totally new faculties.

(6) The possible development of foreign educational opportunities in the many optometry schools around the globe now employing virtually no advanced degree personnel.

All of these, and perhaps other factors, all point to the probability of increased rather than decreased demands in the approaching decade.

DISCUSSION AND CONCLUSION

Surveys of the demand and supply of optometric teachers during the next decade indicate that the graduate training in physiological optics and equivalent programs will have to be stepped up to approximately six times the production rate of these programs during the past 10 years for M.S. or equivalent degrees, and approximately three times for Ph.D. or equivalent degrees.

These indications do not include allowances for many incidental factors, all of which suggest that these estimates are too conservative.

There are no indications that this increased rate will occur automatically or naturally, wherefore steps should be taken to encourage more optometry graduates to pursue graduate study toward advanced degrees. This encouragement will undoubtedly have to include provisions for increased financial support of graduate study.

COMMENTS ON "THE TOTALITY OF VISION"*

Henry A. Knoll†
Department of Biophysics
University of California, Medical Center
Los Angeles, California

A recent article by Skeffington[1] relates the progress of some very interesting work concerning the variation in refractive state of the eyes of subjects while they are performing various visual tasks. In the introduction Skeffington builds a straw man, whose identity is never

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revealed, and then proceeds to pummel him with quotations by some very impressive authorities. Unfortunately the quotations are without references in at least sixteen instances, and in other cases are incorrectly quoted and in at least one instance the reference is incorrect.

The straw man (according to Skeffington) believes that the ocular media are perfectly transparent, that the crystalline lens is a corrected curve lens, that the retinal image is transmitted to the cortex without alteration, that if the ocular defects are corrected and binocularity is demonstrated then all is well (visually), and finally that the brain has nothing to do with vision. No responsible investigator believes any of these things, and to take up pages in a scientific journal describing such an individual is a sheer waste of valuable space. Wiener[2] and Mann and Pirie,[3] in articles intended for the lay public, make the point that we "see" with our brains. To make this point to the layman is all well and good, but the professional man and the scientist have recognized this fact for a long time and need not be reminded of it. The fact that the straw man is not identified by Skeffington would lend support to the above contention.

It is not this writer's intention to dwell upon the bibliographic shortcomings of Skeffington's article. However, it is extremely frustrating to the reader and poor form on the part of the author to have references incorrectly cited. Skeffington summarized the work of Hayden and lists a reference which does not exist. Gooddy and Reinhold are quoted incorrectly and italics are used which are not in the original. As stated earlier, at least sixteen references are omitted, so that the reader is left in the very difficult position of not being able to refer to the original works.

The final sentence of the article gives Helmholtz credit for the invention of the retinoscope. Bowman is usually given credit for the first description of the use of the fundus reflex as a means of determining refractive error. Cuignet, Landolt, and Gullstrand subsequently described the method in more detail.[4]

Who is your straw man, Dr. Skeffington? Who could possibly discount the role played by the brain in vision when the retina itself is but an outcropping of the brain?

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TESTS FOR GLASS AND PLASTIC SAFETY LENSES*

G. P. Elmstrom†
El Segundo, California

The emphasis during the last decade on industrial optometry has made it essential that optometrists, particularly those in industrialized communities, know about safety lenses. There are numerous manufacturers with many claims for each type of safety lens. This promotion has partially clouded the more basic and established testing procedures for safety lenses, most of which are stipulated by either or both the U. S. Bureau of Standards or the American Standards Association.

IMPACT RESISTANCE

Most optometrists are acquainted to some degree with this popular test for the "safeness" of safety lenses. There have been two standards established by the U. S. Bureau of Standards. The less demanding test requires that a lens sustain the force of a 5/8-inch diameter steel ball, weighing 16 grams, dropped freely from a height of 1 meter onto the horizontal convex outer surface of the lens. The lens must be contained by a rubber shock device. The more rigid test requires the same procedure except for a 7/8-inch diameter steel ball dropped from a distance of 50 inches. Clinically, optometrists do not use such a "drop" test, but rely upon the Bausch and Lomb Bal-Safe Impact Tester, which is convenient and simulates this second rigid standard.

PIERCE RESISTANCE

The piercing test was developed by manufacturers to supplement the impact test since a lens might pass the impact test and still not sustain the force of a small pointed missile. A pencil-shaped steel bar, weighing 44 grams, with a steel sewing machine needle on the end, is dropped 87 inches through a tube onto the front convex surface of the lens. Plastic lenses, in general, sustain such a shock better than glass safety lenses.

TESTS FOR ABRASION

Plastic lens manufacturers frequently publish supporting literature based upon various types of abrasion tests to show the superiority of

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†Optometrist. Chairman, Material Standards Committee, California Optometric Association. Chairman, Material Standards Committee, Los Angeles County Optometric Association.

some types of plastics over others. The fundamental tests for abrasion are: (a) the Taber Abrasion Wheel Test which is the more popular abrasion test. The lens is placed under two abrasion wheels consisting of emery paper and with slight contact. The lens is rotated clockwise and is inspected for haze after 20, 40, 60, 80 and 100 turns. Haze is plotted by percentage, 100 percent haze being a completely translucent lens. Ophthalmic glass shows 0.5 percent haze upon the completion of 120 revolutions on the abrasion wheel, meaning it is 1/200 toward translucent. The older type ophthalmic plastic, thermo-plastic, shows an extremely high vulnerability toward hazing with 12 percent hazing after only 20 revolutions. Newer plastics used in making lenses are considerably improved but do not measure up to the resistance of glass. (b) The Falling Emery Test which is performed by permitting free falling emery particles to be dropped through a hollow tube from a height of 18 inches upon the lens positioned at a 45° angle to the falling particles. The amount of emery by weight dropped is plotted against the haze percentage. The standard amounts, as with the revolutions in the abrasion wheel test, are 200, 400, 600, 800 and 1,000 grams of emery. 400 grams of emery with a stipulated drop will lead to 23 percent haze with glass; thermo-plastics will have 66 percent haze and some of the newer plastics will be better than glass and have as little as 13 percent haze.

RESISTANCE TO CHEMICALS

Sample lenses are weighed, completely immersed in various chemical solutions for a period of seven days, removed and carefully weighed and examined to determine if there has been a weight or/and structural change. The acids and alkalies used are in the concentration commonly used in current industrial and manufacturing processes.

THERMOSTABILITY

This test to determine the resistance to cold or heat is performed by placing the lens on cotton in a water bath at 105° for five minutes, then removing and allowing the lens to cool on a flat surface, concave side down. The lens is checked by the lensometer and lens clock to determine changes, if any, within 0.12 diopter power. Laboratory temperature is 78° with relative humidity at 45 percent. Extreme testing for thermostability may include boiling as well as freezing temperatures.

OPTICAL QUALITIES

Optical qualities are subdivided into two commonly accepted patterns, namely: (a) Prismatic Effect, which is generally employed for testing plano safety lenses. An 8 power telescope with an effective aperature of 1 inch is equipped with cross hairs on the focal plane

of the occluder. The telescope is focused upon an illuminated target at a distance of 35 feet. The target consists of a central dot and a concentric circle 0.5 inches in diameter. The telescope is so aligned as to present the image dot falling right upon the crossed hairs. The lens under scrutiny is placed in front of the objective lens of the telescope. Should the cross intersecting point fall within the image of the circle the prismatic power is within 0.06 Δ. (b) Refractive Power, the telescope is calibrated by successively locating the position of the best focus with standard lenses of — 0.06 D. and + 0.06 D. These positions are marked on the draw tube. The test lens is placed in front of the telescopic objective. Should the position of best focus fall inside the telescope marked position the refractive power is within the common specified plus or minus 0.06 Δ

There are at least eight sets of standards for evaluating ophthalmic lenses which compels an author or investigator to chose one set to be followed for testing. At times the manufacturer follows one set of standards, the laboratory another, and the practitioner still another. The American Standards Association is now attempting to resolve these differences and to establish *one* set of principles for all. Some *other* standards applied to prescription safety lenses are (1) centering of the lens, (2) thickness, (3) power limitations, (4) surface defects interfering with vision, and (5) peripheral lens limitations.

502 RICHMOND ST.
EL SEGUNDO, CALIFORNIA

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TRANSACTIONS OF THE AMERICAN ACADEMY OF OPTOMETRY

A department devoted to announcements, reports, appointments, organization data, news, professional problems and ideals, as these relate to the Academy.

FURTHER NOTES ON THE COMING ACADEMY MEETING

The time has come to make final arrangements to attend the annual meeting of the American Academy of Optometry in Chicago in December. Every Academy member should be there. Hotel reservations now should be made with the Drake Hotel, Lake Shore Drive and Upper Michigan Ave., Chicago 16, Illinois, and some thought be given to actual travel plans.

The meeting will be one of the most elaborate ever held by the Academy, with a programmed list of speakers numbering more than 100, who will cover all phases of optometric practice in this big educational week.

In the last two issues of the Academy Journal the committee has presented the Post-Graduate Courses[1] offered all optometrists by the American Academy of Optometry, December 4-6, 1957, and also a list of the Original Papers[2] to be given at the annual meeting of the Academy, December 7-10, 1957, in Chicago, the Drake Hotel. In this issue we publish the programs of the *Academy Sections* to be held during the annual meeting and also the program for the *Symposium on Orthoptics* which will be presented by members, jointly to the Academy and the Illinois Optometric Association, at a special Sunday afternoon meeting December 8, in Chicago, at the Morrison Hotel. These programs follow:

SECTION ON ORTHOPTICS

Sunday, December 8, 1957. (9:00 A.M. to 11:00 A.M.)

I. Orthoptics Abroad. Meredith W. Morgan, Jr., O.D., Ph.D., School of Optometry, University of California, Berkeley.

II. Orthoptics With Simple Devices. Bernard E. Vodnoy, O.D. South Bend, Indiana.

III. Technique for Observing Haidenger's Brushes and Variations from Normal Observations. Neal J. Bailey, O.D., Ph.D.

[1]Vincent J. Ellerbrock, et al., Post-Graduate Courses of the American Academy of Optometry. Am. J. Optom. & Arch. Am. Acad. Optom. 34.8.451-462, 1957, and 34.9.511-522, 1957.

[2]Carel C. Koch. Notes on Coming Academy Program. Am. J. Optom. & Arch. Am. Acad. Optom. 34.9.504-506, 1957.

Division of Optometry, Indiana University, Bloomington, Indiana.

IV. The Effect of Visual Training on the A.C.A. Ratio. Leo Manas, O.D., Illinois College of Optometry, Chicago.

Monday, December 9, 1957. (9:00 A. M. to 11:00 A. M.)

I. Visual Problems in Reading and Optometric Limits. Lois Bing, O.D., Shaker Heights, Ohio.

II. Research on Visual Problems in Reading. Charles B. Huelsman, Jr., Ph.D., Miami University, School of Education, Oxford, Ohio.

III. Optometric Help with Visual Problems in Reading. Daniel Woolf, O.D., Ph.D., New York City.

Tuesday, December 10, 1957. (9:00 A. M. to 11:00 A. M.)

I. Dynamic Tests of Fusional Reserve and Accommodation with Prism Reader. Harold A. Solan, O.D., New York City.

II. Perception Training Case Reports. Daniel Woolf, O.D., Ph.D., New York City.

III. Case Reports of Amblyopia. Ralph LeDrew, O.D., Edmonton, Alberta, Canada.

IV. Orthoptic Case Reports and Discussion. J. Donald Kratz, O.D., Pennsylvania State College of Optometry, Philadelphia.

Section Chairman, John Zettel, O.D., Cincinnati.

SECTION OF OCCUPATIONAL OPTOMETRY AND INDUSTRIAL EYE WORK

Sunday, December 8, 1957. (9:00 A. M. to 11:00 A. M.)

I. Forms and Techniques for Making Industrial Vision Reports. A two hour report and demonstration with a question and answer period. Henry W. Hofstetter, O.D., Ph.D., director, Division of Optometry, Indiana University, Bloomington, Indiana.

Monday, December 9, 1957. (9:00 A. M. to 11:00 A. M.)

I. A New Syllabus for an Optometric Course on Illumination. A two hour session in which present work is reviewed and new suggestions are discussed. Sylvester Guth, E.E., D.O.S., manager, Radiant Energy Effects Laboratory, General Electric Company, Nela Park, Cleveland.

Tuesday, December 10, 1957. (9:00 A. M. to 11:00 A. M.)

I. An Evaluation of the Validity of the Massachusetts Vision Tester. Lieutenant Robert S. Arner, United States Air Force, with panel discussion.

Section Chairman, Herman Sager, O.D., Optometry Section, Eye Department, Sperry Gyroscope Company, Lake Success, New York.

SECTION ON PATHOLOGY

Sunday, December 8, 1957. (9:00 A. M. to 11:00 A. M.)

Aspects of Interprofessional Relations.

I. Attitude of Optometry Towards Medicine. (Introduction)
II. Legislation and the Dispensing Optician.
III. Technical Education for Opticianry.
IV. Glaucoma and Interprofessional Relations.
V. Is Optometry a Drugless Form of Healing?
VI. The New Public Relations Front for Ophthalmology.
VII. The Dispensing Optician as a Potential Steerer and Capper.
VIII. Is there an Over Emphasis on Eye Pathology?
IX. Handling Patient Referrals.

Carel C. Koch, O.D., Minneapolis, and a panel of discussion leaders from the Executive Council.

Monday, December 9, 1957. (9:00 A. M. to 11:00 A. M.)

I. Photography of the External Eye as a Useful Technique in Optometric Practice. The general usefulness of photography will be reviewed and examples of this type of work will be shown. Jack Harvey Prince, F.B.O.A., Department of Ophthalmology, Medical School, The Ohio State University, Columbus. Supplementary material on this subject will be presented by Richard C. Schiller, O.D., Marshalltown, Iowa, and Arthur H. Tweedle, O.D., Midland, Ontario, Canada.
II. A discussion and review of the Harrington-Flocks instrument used as a rapid screening device in visual field testing. Harold M. Fisher, O.D., New York City, and Monroe J. Hirsch, O.D., Ph.D., Ojai, California.

Tuesday, December 10, 1957. (9:00 A. M. to 11:00 A. M.)

I. A review and discussion of the new Glaucoma Detection Project as proposed as a part of the post-graduate educational program for optometry, by the Southern California Chapter, American Academy of Optometry. Arthur E. Hoare, O.D., Glendale, California, and Monroe J. Hirsch, O.D., Ph.D., Ojai, California.

Section Chairman, Jay M. Enoch, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus.

SECTION ON CONTACT LENS FITTING AND CORRECTION OF SUBNORMAL VISION

Sunday, December 8, 1957. (9:00 A. M. to 11:00 A. M.)

I. Rehabilitation of the Subnormal Vision Patient. A two-hour

clinical demonstration. William Feinbloom, O.D., Ph.D., New York City.

Monday, December 9, 1957. (9:00 A. M. to 11:00 A. M.)

I. A Report of the 1957 meeting of the International Contact Lens Congress in Germany and Recent Advances in Contact Lens Fitting and Contact Lenses. John C. Neill, O.D., professor of optometry, Pennsylvania State College of Optometry, Philadelphia.

II. Contact Lens Practice in England. Norman Bier, F.B.O.A., London, England.

Tuesday, December 10, 1957. (9:00 A. M. to 11:00 A. M.)

I. Members and guests attending this Section meeting will visit the Chicago Lighthouse for the Blind. The program there will consist of a conducted tour of the Lighthouse workshops, the Helen Keller Room and the subnormal vision examination room where a complete display of visual aids and related materials will be organized. In addition, selected members of the professional staff will address the Section on important aspects of subnormal vision and methods of correcting these problems with optical aids.

Section Chairman, Bernard Mazow, O.D., 4118 Fannin, Houston, Texas.

SECTION ON ANISEIKONIA AND REFRACTIVE PROBLEMS

Sunday, December 8, 1957. (9:00 A. M. to 11:00 A. M.)

I. Charts and explanations of simplified techniques in aniseikonic examination. Harold M. Fisher, O.D., New York City.

Monday, December 9, 1957. (9:00 A. M. to 11:00 A. M.)

I. Recent Developments in Optometric Refractive Techniques. Robert E. Bannon, O.D., Bureau of Visual Science, American Optical Company, Southbridge, Massachusetts.

Tuesday, December 10, 1957. (9:00 A. M. to 11:00 A. M.)

I. Selected case histories of aniseikonia and refractive problems. Group discussion.

Section Chairman, Oscar L. McCulloch, O.D., Holyoke, Massachusetts.

ORTHOPTIC SYMPOSIUM

Joint meeting of the American Academy of Optometry and the Illinois Optometric Association at the Morrison Hotel.

Sunday, December 8, 1957. (2:30 P. M. to 5:30 P. M.)

I. Introductory Remarks. Meredith W. Morgan, Jr., School of Optometry, University of California, Berkeley.

II. Diagnosis and Correction of Suppression. Daniel Woolf, O.D., Ph.D., New York City.

III. Diagnosis and Correction of Amblyopia. Max Schapero, O.D., Los Angeles College of Optometry, Los Angeles.

IV. Diagnosis and Correction of Eccentric Fixation. Neal J. Bailey, O.D., Ph.D., Division of Optometry, Indiana University, Bloomington, Indiana.

V. Diagnosis and Correction of Anomalous Correspondence. Jack Fugate, O.D., Ph.D., School of Optometry, The Ohio State University, Columbus.

VI. Prognosis in Strabismus. Merton Flom, O.D., Ph.D., School of Optometry, University of California, Berkeley.

Section Chairman, John Zettel, O.D., Cincinnati.

BANQUET SPEAKER

In addition, the announcement may now be made of the banquet speaker and his subject. Henry W. Hofstetter, O.D., Ph.D., director of the Division of Optometry, Indiana University, Bloomington, Indiana, will speak on *"A Comprehensive Survey of the Role of Optometry and Its Educational Needs."* As usual, our banquet speakers are selected with great care and the message they bring is of considerable importance to all of us. Dr. Hofstetter is fortunately too well known to Academy members and the readers of this Journal to require further introduction and he will follow the custom of presenting a paper at the banquet of far-reaching significance to the entire profession.

The banquet of the Academy for years has been known as the *Annual Formal Round Table Dinner* and members and guests are requested* to wear dinner coats and black ties. This event will be held Monday, December 9, at 7:15 P. M. at the Drake Hotel. Members of the Illinois Optometric Association and their wives have been invited to attend. The banquet will follow a cocktail hour.

RALPH E. WICK
DONALD A. SPRINGER

NEW MEMBERS

The following optometrists have been elected to Fellowship in the American Academy of Optometry. The Executive Council welcomes these new members.

Capt. Albert V. Alder, U.S.A.F. (M.S.C.), 1035 Highview Drive, Xenia, Ohio.

Lt. Louis A. Baker, U.S.A.F. (M.S.C.), 2750 U.S.A.F. Hospital,

*Most do, but this is not a requirement.

Wright-Patterson A.F.B., Dayton, Ohio.

Dr. Salin Baker, 329 West Main St., Frankfort, Kentucky.

Mr. Ronald A. Baxter, 8 The Parade, Burgh Heath, Tadworth, Surrey, England.

Lt. Willard B. Bleything, College of Optometry, Pacific University, Forest Grove, Oregon.

Dr. Frank Brisley, 109 East Third St., Maysville, Kentucky.

Dr. David Cline, 8511 S. Vermont, Los Angeles, California.

Dr. Graham A. Craig, 214 Boyd Bldg., 385 Portage Ave., Winnipeg, Manitoba, Canada.

Dr. James T. Crosby, Jr., 1528 Stafford Ave., Hayward, California.

Capt. Manie J. Ezell, 7250th U.S.A.F. Hospital, A.P.O. 254, c/o PM., New York, New York.

Mr. Keith N. Fairweather, 9 Dollar St., Cirencester, Gloucestershire, England.

Dr. Lawrence S. Geiger, 110 E. Third St., Sedalia, Missouri.

Dr. Carsten Glahn, 169 Colborne St. E., Oakville, Ontario, Canada.

Dr. Earl Golden, 205 S. Main St., Herkimer, New York .

Lt. Lewis C. Gordonson, 6000 U.S.A.F. Disp., A.P.O. 925, c/o PM., San Francisco, California.

Dr. Joseph B. Gutstein, 917 Prudden Bldg., Lansing, Michigan.

Dr. Chester H. Johnson, 220 Hampden Road, Upper Darby, Pennsylvania.

Mr. John G. Lyons, 55 Romford Road, Chigwell, Essex, England.

Dr. Berne L. Pearl, Illinois College of Optometry, 3241 S. Michigan Ave., Chicago, Illinois.

Mr. William H. Phillips, Old Library House, Malvern, Dorcs. England.

Dr. W. B. Porter, 403 Sixth St., Shelbyville, Kentucky.

Dr. S. Harold Roberts, 162 N. State St., Chicago, Illinois.

Dr. Raymond R. Roy, 318 S.W. Alder St., Portland, Oregon.

Dr. Vernon I. Ryan, 2024 72nd Ave., Philadelphia, Pennsylvania.

Dr. LeRoy Robert Woodring, 922 Hamilton St., Allentown, Pennsylvania.

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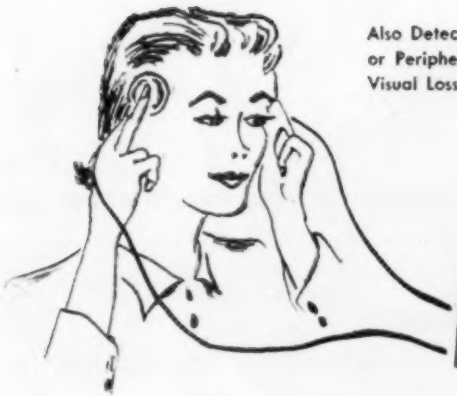

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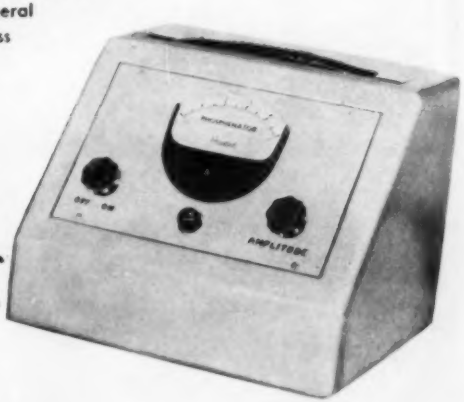

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Base Curves 425-625-825-10
Adds +50 thru +350
Segment Sizes 20, 22 m/m

Curved Top Trifocal 60m/m Round
Base Curves 450-650-8-10
Adds +150 thru +300
Segment Sizes 24m/m
Intermediate 7m/m, 50% of Reading Portion

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Adds +150 thru +350
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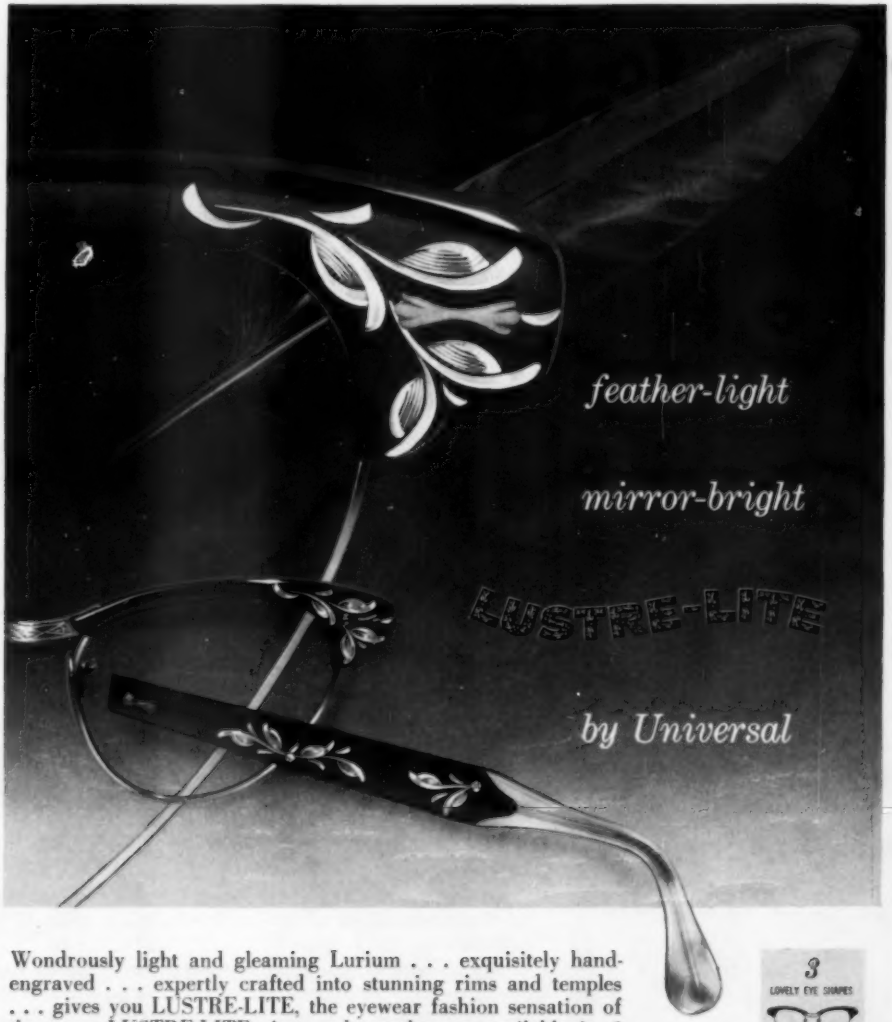

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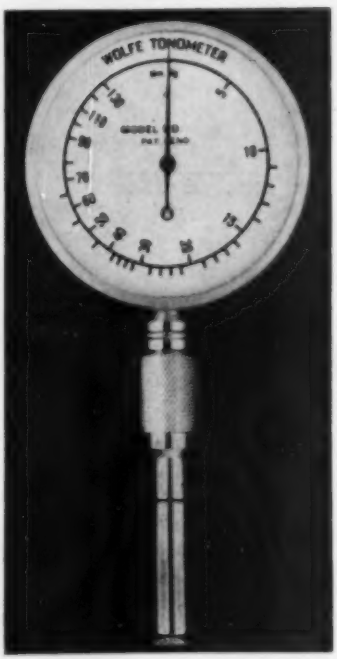

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